Workplace connectivity : A study of its impact on self-assessed productivity.

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Workplace Connectivity: A study of its impact on self-assessed productivity

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A thesis submitted in partial fulfilment of the requirements of

Sheffield Hallam University

for the degree of Doctor of Philosophy

July 2005

Abstract

Previous researchers have had difficulty in defining what constitutes office productivity, especially in 'knowledge' environments rather than 'processing' environments. The main body of published research that attempts to address the link largely addresses the physical environment. It falls into two main categories, those of office layout and office comfort. It must be noted that much of the physical environment literature lacks any theoretical framework. This study developed a validated theoretical framework for the evaluation of office productivity, and included components to represent both the physical and the behavioural environment. It is proposed that by adopting such an approach, insights into the dynamic nature, or connectivity, of office environments can be established. The main objective of this thesis was to investigate the effects of the office environment on its occupant's perceived productivity.

The study's strength is that it is based on two sizable data sets. Whilst the data collected contain data about the physical characteristics of the office environment, it had in addition data pertaining to the behavioural environment. The categorical data collected provided a unique opportunity to undertake an analysis of office occupiers by work process type. One of the key contributions of this study was the development of the components of office productivity, which were: comfort, office layout, informal interaction points, environmental services, designated areas, interaction and distraction. The components were reduced to four in preparation for a more detailed statistical analysis. The four distinct components were comfort, office layout, interaction and distraction.

This study establishes that it is the behavioural environment that has the greatest impact on office productivity. It demonstrates that it is the dynamic elements of the office environment, interaction and distraction that are perceived as having the bigger positive and negative influences on self assessed productivity and explains the finding in a model in which knowledge creation and knowledge transfer, and ultimately productivity, are enabled through various forms of communication.

Managers responsible for office environments can use the techniques, and the analysis procedures, to assist in evaluating and identifying productive office environments. The positive results can be just as important to the manager as the negative, as they give an indication as to areas in the office environment that are working correctly. A comparative approach between offices can allow best practice solutions to be transferred from one office to another.

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Acknowledgements

This research was only made possible by the assistance, and support, of a number of people to whom I am forever grateful. I am particularly indebted to my supervisors, Professor If Price and Dr Murray Clark, for their guidance, tolerance and encouragement throughout the course of this research. I would also like to thank Phil Askham and James Pinder for their comments on this thesis during the editing stages. I would like to offer a special thanks to John Storr for stimulating and supportive discussions.

I am extremely grateful to all the organisations that have been involved in this study, and to the respondents who took the time, and effort, to complete the research questionnaire. I would also like to acknowledge the support of Sheffield Hallam University, and in particular the Facilities Management Graduate Centre.

Finally, a big thank you to my family. I realise that over the last six years times have been difficult and without their patience, tolerance and support this work would not have been completed. Therefore, I would like to dedicate this thesis to my wife Jane, my daughter Charlotte and my son Philip.

1 Introduction

1.1 Overview

There has been a fundamental shift in the structure of the UK economy from that of an economy based on manufacturing to one more based on service and knowledge. It is therefore estimated that approximately 80% of the UK workforce work in office environments (Oseland, 1999). Since increasing emphasis is being placed on the output of such offices, it is becoming increasingly important to establish the role the office environment plays in the performance of its occupants.

There has been much written on the effects of the office environment on occupiers' productivity, however little evidence has actually been presented. The evidence that does exist largely defines the office environment in physical terms, i.e. the layout of the office and the comfort of its occupants. Whilst there appears to be a general consensus that the office environment has an effect on the occupiers' productivity (Oseland, 1999; Leaman and Bordass, 2000; Clements-Croome, 2000) there does not appear to be a universally accepted theoretical framework that represents office productivity. Consequently there are two main research areas that require further development, firstly the measurement of productivity, and secondly the evaluation of the effects of the office environment on the productivity of its occupants.

This research focuses on the development of a theoretical framework for office productivity, in order to further understand the components of the office environment, and their relative impact on the occupiers' productivity. The research broadens the understanding of the office environment from that of a purely physical environment to include the behavioural environment. This provides an insight into the dynamic nature, or connectivity, of office environments. The main objective of this thesis is concerned with investigating the effects the office environment has on its occupant's perceived productivity.

1.2 Background

I first became aware of the role that office environments played in the productivity of its occupants when I was a manager responsible for a space utilisation and relocation project in 1995. However it was not until I joined Sheffield Hallam University in 1996, and became involved in both teaching and researching space management, that my interest in this area developed. The main reason for the interest in space management is that it crosses a number of boundaries; property management, facilities management, environmental psychology, organisational culture and business performance measurement. Also topics that cross a number of disciplines offer opportunities to contribute to knowledge. Fleming and Storr (1999) established, whilst evaluating lecture theatres that two main bodies of literature existed. The bodies of literature were those of lecture theatre design and educational pedagogy, although little literature existed that linked the two, i.e. the existence of professional silos. It could be argued that professional boundaries exist in the area of office space management, and this research attempts to collapse some of those boundaries (Haynes *et al*, 2000).

1.3 Context and rationale

The nature of office work has changed over the last century from that of a passive and static activity, to that of a dynamic and flexible activity. The changing nature of office work has created tensions in office design. The challenge, for modern office designers, is to create environments that support the ways that people work, and act as enablers of work processes, and not as disablers. Laing (1991) acknowledged the existence of the potential tension between office design and the work processes, and argued that the conventional office design, which was based on passive individual process work, was restricting organisations ability to be creative.

The foundations of office design can be traced back to the ideas of scientific management as proposed by Frederick Taylor, with standardisation of office layouts (Laing, 1991 & 1993; Duffy, 2000). Laing (1991) proposed that the office environment had reached a critical point in its evolution, and called for "Post- Fordism" in office design. Since the nature of work within businesses had changed, i.e. with the notion of work time and space being questioned, there was also a requirement for change in office design. Laing (1993) develops the argument by proposing that the main thrust of post-Fordism in the office environment is flexibility. The proposal being that flexibility is the way to productivity improvements.

Grimshaw (1999) acknowledges that the relationships between organisations, employees and space are changing, i.e. postmodernism, and proposes that the core of facilities management relates to the management of these changes. However, he acknowledges that whilst FM claims to be strategic, in practice FM practitioners tend to function at an operational level. Duffy (2000) reiterates the constant pressure on facilities managers to be operational, and therefore identifies the difficulty facilities managers have as change agents acting at a strategic level.

> *"The design of the working environment has been considered by the vast majority of clients as a marginal and technical matter, best left to experts to sort out." (Duffy, 2000, p 371)*

Duffy (2000) identifies that the discipline of facilities management has tended to be dominated by, and ultimately defined as a cost cutting discipline. He argues that if the profession had been more research based, then the pressures for cost cutting could have been resisted, allowing the case for the design of the work environment to support strategic business to be made. The call for facilities management research, and the development of a theoretical framework, is well supported by academia (Nutt,1999; Grimshaw,1999; Price, 2001 and Cairns, 2003).

The drive for greater efficiency of property provision, and ultimately cost reduction, is further fuelled by a RICS report – *Property in business – a waste of space?* (Bootle and Kalyan, 2002). The report claims that £18 billion a year is thrown away through the inefficient use of space. The report proposes that whilst property is often the second highest cost after wages, it is rarely on the boardroom agenda. Whilst Bootle and Kalyan (2002) establishes that £6.5 billion a year can be saved by adopting new working practises such as "hot-desking", the main push towards new work methods is based on reduced costs, rather than new work methods to improve business performance.

The rationale as to why the real estate and facilities management departments have developed into cost cutting departments can be understood by an illustrative example from Weatherhead (1997).

Table 1:1 A 5 % saving in real estate costs increases gross profit by 9%

Existing trading situation			
	Turnover		100
	Total Costs		90
	Operating Profit		10
	Total costs of 90% are made up of:		
	real estate	20% =	18
	other costs	80% =	72
			90
Reduce real estate costs by 5%			
	Total costs are now:		
	real estate		17.1
	other costs		72
			89.1
New trading situation after reduction in real estate costs			
	Turnover		100
	Total Costs		89.1
	Operating Profit		10.9 (9%) increase

Table 1:2 A 5 % increase in productivity increases profit by 50%

Existing trading situation			
	Turnover		100
	Total Costs		90
	Operating Profit		10
	Total costs of 90% are made up of:		
	real estate	20% =	18
	other costs	80% =	72
			90
Increase Productivity by 5%			
	Turnover is now		105
New trading situation after increase in productivity			
	Turnover		105
	Total Costs		90
	Operating Profit		15 (50% increase)

The information presented in Table 1:1 highlights the fact that a 5 % reduction in real estate costs can translate directly to the bottom line of the business with a 9% increase in operating profit. Acknowledging that this is an illustrative example it does assist in understanding why the real estate and facilities management departments have been perceived as cost cutting departments.

However, an alternative approach can be developed, if it is assumed that:

I. Staff costs are equivalent to the other costs used in the illustrative example.

II. A 5 % increase in productivity is achieved instead of a 5% reduction in real estate costs.

Table 1:2 establishes that a relatively small increase in productivity (5%) can have a significant impact on operating profit (a 50% increase). The limitations of the illustrative examples are acknowledged, however it does illustrate the point that cost cutting will achieve some increase in profit, but the greater increases in profit can be achieved by addressing the productivity improvement.

If the facilities management department is to be seen by the organisation as more than a cost cutting department then it is important to demonstrate performance metrics in more than cost cutting terms. Ideally the facilities management department should link the facilities performance measurements to those of the organisation, thereby demonstrating the impact of the facilities on the performance of the organisation.

Haynes *et al* (2000) undertook a literature review to establish if any evidence existed that linked the impact of buildings and workplaces to the business performance of the organisation[1]. The main findings can be summarised as follows:

I. Previous research had produced little overlap between the three main arenas of: Property and real estate, Facilities and workplace and Business and performance

II. No validated theoretical framework existed that linked the performance of the workplace to the performance of the organisation.

III. The literature relating to office design, tended to concentrate on the open-plan verses cellular office debate. The metrics used in the debate tended to be that of cost. Therefore the issues identified tended to revolve around operational issues rather than strategic issues.

IV. The link between organisational culture and the office environment appears to be lost[2].

V. Office environments are more than just furniture and walls, they are also places where people interact to create and transfer knowledge. Ward & Holton (2000) argue the importance of the linkage between space and knowledge creation, but acknowledge that managing space is probably the least appreciated tool of contemporary knowledge management.

These main findings attempt to summarise the debate relating the office environment to occupier productivity. Whilst the post-fordist office environment, which embraces organisational culture and knowledge creation, may be a desired position, it is clear that the existing literature is grounded in the cost reduction paradigm. To change the debate from cost to business performance there is a requirement to put into place a new theoretical framework.

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[1] This review was an output of the Occupier.Org project, which involved a number of staff from Sheffield Hallam University and was led by Prof. If Price. The executive summary of the report can be seen in Appendix A.

[2] Franklin Becker first made this link in 1990 when he termed the phrase office ecology.

This research will aim to address some of the issues identified in the occupier.org research project. This thesis will provide evidence of new and original findings, which add to the office productivity debate.

It is proposed that the main contributions to knowledge of this study are as follows:

A major contribution of this study is the development of office productivity from a theoretical framework to a validated research method that allows reliable assessment of office productivity. The study's strength is that it is based on two sizable data sets, (996 respondents and 426 respondents) which when combined provide a data set of 1,422 responses. Whilst the data collected contain evidence about the physical characteristics of the office environment, it has in addition data pertaining to the behavioural environment. The categorical data collected provide a unique opportunity to undertake an analysis by work process type.

This study adds directly to the workplace literature by broadening the debate. The debate around office environments has tended to revolve around open-plan offices and cellular offices. The main line of argument developed tends to be one of cost reduction, i.e. open-plan offices are more cost effective than cellular offices. The logical conclusion of this line of argument is that as many people as possible should be put into open-plan offices. Unfortunately, this one-size fit all approach does not accommodate different work processes. Whilst some work processes require the occupant to work privately, others require more group type working. This study allows office occupants to be categorised by their work type, thereby allowing a more detailed analysis of office occupants to be undertaken. Also the analysis by work process also gives an indication as to the office culture, i.e. the degree of autonomy a office worker has, will be very much determined by the type of prevailing culture.

A further contribution of this study is a broadening of the understanding of the office environment. Traditionally, the office environment has largely been considered to be the physical environment. The main physical components are layout and comfort. This approach tends to assume that the office occupant is a passive element of the office environment. This study will establish that the behavioural environment is an integral component of office productivity. It will be proposed that it is the dynamic elements of the office environment that enable knowledge creation and knowledge transfer, and ultimately productivity, through various forms of communication.

Managers responsible for office environments can use the techniques, and the analysis procedures, developed to evaluate the productivity of office environments[3]. This would assist managers to establish office environments that were having a negative effect on its occupants, and the model developed would assist in establishing the major cause of those negative impacts. The positive results can be just as important to the manager as the negative, as this is an indication as to areas in the office environment that are working correctly. A comparative approach between offices can allow best practice solutions to be transferred from one office to another office. Models developed in this study can be used over time, thereby providing a monitoring system that continually evaluates the match between the occupants and their office environment. Such information can be used to adapt the office environment to meet changing office occupant demands.

1.4 Research aims

The main aims of this study can be summarised as follows:

I. Conduct a critical review of the literature to establish the strengths and weaknesses of the current state of office productive knowledge.

II. Develop a theoretical framework to represent office productivity, consisting of both physical and behavioural components.

III. Demonstrate that it is the behavioural components of interaction and distraction that have the greater impact on office productivity.

IV. Establish if office occupiers, who adopt different work styles, can be segmented based on differences of perceived productivity with regards to the physical and behavioural environment.

[3] A number of projects have been undertaken which have applied the techniques developed in this study.

1.5 Research approach

When the research began there were numerous claims of office environments having effects on productivity but little evidence, supported by a literature review conducted by Haynes *et al* (2000). It was this lack of empirical evidence that formed the basis for this research[4].

The first dataset was obtained in 2000, from a research project for a local authority research forum that was managed by FMGC at Sheffield Hallam University. The data were collected using a paper based questionnaire survey. In total 10 local authorities took part in the research project, with responses from 26 offices. The actual number of respondents was 996 from a population of 4,338 office occupants.

The second data set was obtained in 2002, from the private sector, though a piece of contract research. This additional dataset provided an opportunity to test the findings of the first dataset. The data set was collected from one company consisting of four main buildings, which formed the company's head office. The total number of head office staff was 800. The data were collected using an online questionnaire with a response rate of 53%, i.e. 422 respondents.

The data from both surveys were used as a basis to develop a model and subsequent statistical analysis techniques. Factor analysis was used as the main technique to develop an understanding of the underlying concepts of office productivity. Factor analysis was conducted on three separate data sets. They were the local authority data set, the private sector dataset, and finally a combined data set. Once robust components had been established the results of the combined data sets were exposed to further statistical analysis.

[4] It is acknowledged that the literature has developed since the start of this study and this is specifically addressed in the literature review chapter.

1.6 Structure of the thesis

Following this introductory chapter, this thesis is presented in 5 main chapters, as can be seen in Figure 1.1.

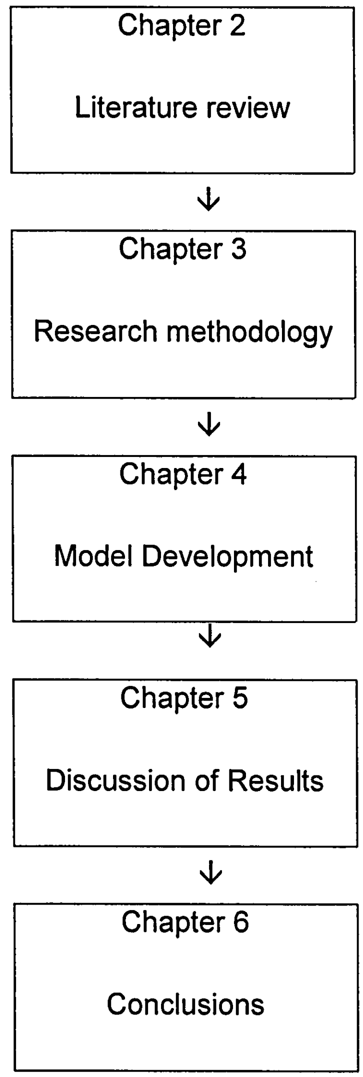

Figure 1.1 Structure of thesis

Chapter 2 critically reviews the literature that claims to link the office environment with the productivity of its occupants. The first part of Chapter 2 addresses the issues of office productivity measurement, focusing on the range of office productivity definitions and measurement techniques. Chapter 2 develops to critically review the research that attempts to link the physical environment to office productivity. This is followed by a critical review of the literature that attempts to link the behavioural environment to office productivity. Chapter 2 concludes by establishing gaps in the literature, and proposes a theoretical framework for office productivity.

Chapter 3 describes the research methodology that has formed the basis for this study. The first part of the chapter explicitly discusses the philosophical foundations on which the study was built. This part of the chapter aims to address the philosophical debate surrounding facilities management research in general, and workplace research in particular. The second part of Chapter 3 presents the rationale and justification for the research design. This includes the development of the survey instrument and consists of both the design, and the data collection processes. The final section of Chapter 3 presents an overview of the analysis techniques used in testing the research hypotheses.

The first part of Chapter 4 uses factor analysis as a means of data reduction to provide underlying structure to the evaluative variables used in the study. The reduction of the variables to components offers an insight into the concepts of office productivity. The chapter develops to demonstrate rigour of evaluation, and justification of the decision making process. Both the data sets used in this study are compared and contrasted as a means for validating the components created. The final sections of Chapter 4 consist of scale development, which allows quantitative values to be attached to the components for further analysis.

Chapter 5 uses the four concepts, previously derived in Chapter 4, as the new evaluative variables. The concepts are then used as the basis of analysis for the different work patterns. The analysis consists of two major components. The first part of the analysis uses data exploratory techniques to evaluate the concepts within each of the four work patterns. The second part of the analysis applies a range of confirmatory statistical techniques, using the concepts as the common metric of analysis. This approach allows statistical comparisons to be made between the work patterns and the concepts.

The concluding chapter is Chapter 6. This chapter draws together all the main findings of the study. Also included are reflections on the research process and recommendations for further research.

Chapter 2

Literature review

2 Literature review

2.1 Introduction

This chapter aims to review the literature associated with the measurement of office productivity. Particular attention is given to literature that claims to link the office environment with the productivity of its occupants. Issues of measurement are reviewed in an attempt to establish appropriate metrics for the measurement of office productivity.

The majority of the literature that attempts to link office environments and productivity considers the office environment to be a tangible physical environment. Issues of comfort and layout are the two main tangible components of the office environment that are reviewed.

The latter part of the literature review concentrates on the literature that attempts to link the behavioural components of the office environment with occupiers' productivity. It will be established that this is an underdeveloped area, and whilst conceptual debate exists, there is a requirement for further research-based evidence.

The literature review will demonstrate the need for, and propose, an office productivity theoretical framework, which links together the physical environment, the behavioural environment and the work processes of the office occupants. The structure of the literature review can be seen in Figure 2.1

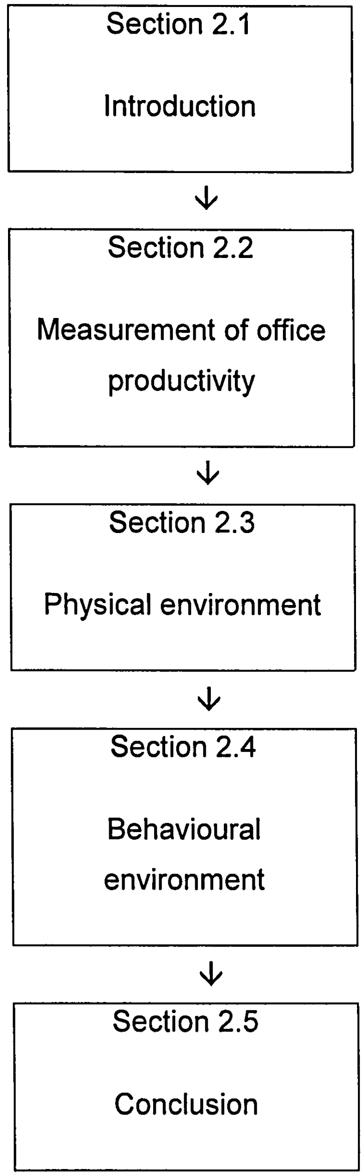

Figure 2.1 Structure of Chapter 2

2.2 Measurement of office productivity

This section addresses the theoretical discussion relating to the measurement of office productivity. It aims to set the historical context of office productivity measurement, and demonstrate the difficulty in defining office productivity. It will be demonstrated that this lack of clear definition has led to a range of different approaches and metrics of measurement. The final part, of this section, aims to establish that there are two competing paradigms: the cost reduction paradigm, and the human contribution paradigm.

2.2.1 Historical context

During the start of the twentieth century the prevailing paradigm with regards to the design and management of work process was that of scientific management (Taylor, 1911). The methodology proposed by Frederick Taylor was that if time and motion studies were undertaken then the most efficient way of task performance could be identified. Once this optimum way of performing any given task was established, it was then standardised so that all employees could then adopt the optimum work method. The strength, and ultimately the weakness, of this approach is that the worker was perceived as a potential source of error and therefore their direct contribution had to be minimised as much as possible, through not only standardised work methods, but also standardised working environments (Stallworth & Ward, 1996).

> *"Taylor assumed that the sole motivation for workers was money and paid little attention to well being, health or other factors." (Oseland, 1999, p6)* [5]

Oseland (1999) claims that Taylor was well aware of the limitations of his scientific management techniques.

> *"Taylor acknowledged that his methods were only appropriate for factory operatives and would not work for intelligent employees because of increased monotony." (Oseland, 1999, p7)*

Duffy (1998) proposes that the dominant culture of offices in the twentieth century have their roots in the ideas of scientific management proposed by Fredrick Taylor. The transference of Taylor's mechanistic paradigm from factory to office appears to be paralleled by the way that productive offices were measured.

An early example (1904) of an office building designed, and built, on the Taylorist ideas was The Larkin Building in Buffalo, New York (Duffy, 1998). The architect was Frank

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[5] This is a retrospective position on Taylorism, since it could be argued that Taylor was striving to improve the conditions of workers.

Lloyd Wright, and the building was a purpose built headquarters for the Larkin Company. The building was designed to represent an ordered structure, with architect-designed desks, which allowed little freedom of movement for the employees. The clerks working in the building were perceived as units of production (Duffy, 1998)

The Hawthorne studies were early attempts to link the performance of employees to their working environment. The studies took place at the Hawthorne plant, which was part of the Western Electric Company. The research directors were Elton Mayo and F.J. Roethlisberger. The purpose of the research was to establish how a productive and satisfying working environment could be achieved (Roethlisberger & Dickson, 1939).

The research concentrated predominately on human behaviour in the context of the working environment. Over the years two studies produced unexpected and revealing results about how people behaved in their working environment. The two studies were the illumination experiments and the bank wiring observation room study.

The first study related to experiments with changing lighting levels. The study was set up as a traditional experiment with the use of a control group and a test group. The independent variable was the lighting level and the dependent variable was the measured output, i.e. the productivity of the employees. The research team were surprised to find that both groups productivity increased. Clearly there was another intervening variable that the research team had not considered. After conducting a range of tests, with different lighting levels, the researchers concluded that it was actually their presence in the research that was affecting the productivity levels. This discovery came to be known as the Hawthorne effect.

> *"Results of the illumination study are often used as an example of what has come to be known as the Hawthorne effect, a term that describes the phenomenon of individuals altering their behaviour not because of specific changes in the environment, but because of the influence of the person making the changes. At the Hawthorne plant, attention from the researchers apparently motivated workers to raise their productivity. This illumination study demonstrated that interpersonal relations between workers and researchers, much more than levels of illumination, affected productivity."(Smither, 1998, p14)*

The second study related to the observation of piece workers working in a bank wiring room. The employees were paid on piecework, i.e. the more work undertaken the greater the employee's pay. The research team observed that when new employees started with higher productivity levels than the experienced workers, they eventually reduced their levels to be more in line with more experienced workers. This was a form of work restriction. The research team were surprised that set against the backdrop of the Great Depression, with money being particularly tight, that the conforming to the norm of the group was deemed to be more important than individual financial reward (Smither, 1998).

The results of the Hawthorne studies led the research team to conclude that it was the social factors that were more important than the physical factors with regards to employee satisfaction and productivity.

Duffy (1998) cites the Hawthorne studies as clear evidence that any single environmental variable is overlaid with the wider issues of human relations. He goes on to call for a more appropriate approach to measuring environments called " open social-technical systems". Smither (1998) identifies a number of limitations of the Hawthorne studies including faulty methodology, too narrow a focus and underlying assumptions. Cairns (2003) presents further evidence to question the validity of the Hawthorne studies, and therefore claims that challenges to the validity of the studies also leads to challenges to the conclusions of the studies.

Duffy (1998) claims that as a consequence of the Hawthorne studies no serious research into the effects of environmental variables and productivity were undertaken for a number of years. Cairns (2003) maintains that it was the Hawthorne studies that led to the acceptance in organizational theory of the dominance of social over physical factors.

Cairns (2003) goes on to suggest that:

> *"There is no doubt that study of the interrelatedness of the physical and social environments as complex contributors to individual motivation and satisfaction has remained relatively undeveloped, and certainly not part of "mainstream" management studies" (Cairns, 2003, p98)*

It is this lack of development that presents the context for the research presented in this thesis. There is clearly a need to better understand the office environment by evaluating both the physical and the social components, and their respective effect on productivity from the end user's point of view. This "occupier perspective" approach to office environments can also address the criticism that office providers are detached from the office users.

> *"Managers continually plan, build, change and control an organization's physical surroundings, but frequently the impact of specific design or design change on ultimate users of the facility is not fully understood"(Bitner, 1992, p 57)*

Whilst the research methods of the Hawthorne studies can be criticized, their discovery that the working environment consists of more than the physical elements contributed to the development of the human relations movement. Also the Hawthorne studies identified that viewing workers purely in a mechanistic Taylorist way was fundamentally flawed (Smither, 1998). This thesis will present an argument to suggest that this is an approach that has been largely lost in the context of office occupiers and their working environment

2.2.2 Defining office productivity

Before productive office environments can be measured, it would be useful to differentiate between productivity and performance. This is an area that has attracted much debate and disagreement. Sink (1985) proposed that seven dimensions, one of which is productivity, could measure "Organisational Performance".

> *Effectiveness (quality, quantity, meeting targets)*
>
> *Efficiency (ratio of expected resources to those used)*
>
> *Quality (subjectively or objectively assessed quality attributes)*
>
> *Profitability (ratio of total revenues to total costs)*
>
> *Productivity (ratio of quantity of output to input in terms of value/cost)*
>
> *Quality of work life (psycho-social aspects and social response to company)*
>
> *Innovation (applied creativity)*
>
> *(Oseland, 1999, p2)*

The seven dimensions of organisational performance include a number of tangible elements such as efficiency and effectiveness, but also include intangible elements such as quality of work life and innovation (Sink, 1985). However, the definition of productivity is very much of the Taylorist tradition, i.e. quantity driven. In contrast Weisbord (1987) attempts to acknowledge the social side of productive workplaces, by proposing the linkage between productive workplaces and organisational development. This linkage is further developed by Duffy (1990), who proposes that performance measures for buildings should be more innovative, and linked to how the organisations manage change. This was an early attempt to integrate building performance measurement into the change management, or organizational development, of the organisation.

Oseland (1999) supports the definition of productivity presented by Sink (1985), i.e. as a ratio of input to output, having conducted an extensive literature review; he concludes that productivity is generally expressed into terms of efficiency (Oseland,1999). This simplistic approach leads to two possible ways of increasing productivity, either increase outputs for same inputs, or achieve same output with reduced input[6]. However whilst what exactly constitutes an input and what constitutes an output tend to be presented in general terms such as: "the resources used to products or services produced". However, Oseland (1999) develops the debate by acknowledging the complexity of measuring inputs and outputs, especially in today's modern office. Mawson (2002) adds to the debate by stating:

> *"Productivity is comparatively easy to understand and measure in a manufacturing economy, but as our economies have migrated from manufacturing to service and on to knowledge-based, so the whole issue of assessing productivity has become less clear" (Mawson, 2002, p1)*

It is clear that understanding productivity in an office context is more complex than in a manufacturing context, where inputs and outputs can be more easily defined. The specific outputs of an office can be varied, thereby compounding the problem of defining a common metric. This lack of clarity, and agreement, as to what actually constitutes productivity in the office environment has led to a range of

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[6] It should be noted that this approach to measurement appears to have been the prevailing paradigm in office design, i.e. get more people in the same original space or get the same number of people in less space, both having the end result of reducing the individuals space standard (Haynes *et al,* 2000)

different approaches to office productivity measurement. The next section will discuss these approaches, with specific emphasis being placed on evaluation of research-based evidence.

2.2.3 Approaches to measuring office productivity

Part of developing a measure of office productivity is the identification of elements that could be perceived has having a considerable impact on performance. One such element, relevant to the office environment, is information technology (IT). Although in the early 1990s commentators (Brynjolfsson, 1993), were questioning the productivity benefits of IT, relative to the amounts of money invested in its development. Brynjolfsson(1993) identified the "productivity paradox" of information technology, the theory being that the introduction of IT should have led to increases in productivity. However, the net contribution, per head, to GNP output (the high level measure of productivity) fluctuated but, unlike the manufacturing sector, showed no real growth.

Aronoff and Kaplan (1995) undertook a similar analysis to Brynjolfsson (1993), on the role of IT in white-collar productivity, and drew an analogy to the beginning of the twentieth century when increased productivity of manufacturing plants did not occur until the appropriate electrical infrastructure was developed, thereby establishing a time lag before productivity gains could be established. It could be argued that information technology, email, internet and telecommunication systems, could be the new infrastructure, and they have reached such a level that they have had a considerable impact on the way that the people now work in offices in comparison to the office workers of the early 1990's.

This is another illustration of the complex nature of office productivity, and reiterates the question as to what is a suitable and appropriate measurement of office productivity. Aronoff and Kaplan (1995) make an attempt to identify the measures that may be appropriate assessment techniques such as, absence measures, activity logs, attitude and opinion surveys, and direct measures but offer no real theoretical framework to link the measures (Aronoff and Kaplan, 1995).

In an earlier piece of work Kaplan and Aronoff (1994) acknowledged the difficulty in measuring office productivity, but they made the linkage between office environment and quality of work.

> *" A person's work environment directly affects the quality and quantity of work he or she is able to produce." (Aronoff and Kaplan, 1994, p10)*

Whilst Kaplan and Aronoff (1994) propose that the office environment and worker performance are correlated, they produce no data to support this claim. However they do contribute to the debate on productivity measurement at a theoretical level, by acknowledging the office environment as being linked to symbols of power and authority.

> *"Individuals place great importance on the quality of their work setting. This is clearly reflected in the use of higher-quality work settings as a reward for superior performance and as a symbol of elevated status. Comfort, environmental control, space and views to the outside are key amenities. While these features are treated as luxuries, they all have an impact on organisational performance." (Kaplan and Aronoff, 1994, p8)*

One of the conclusions that Kaplan and Aronoff (1994) reach is that in the absence of measurable business value of the work environment, it is left to the senior executive to undertake a leap of faith in the benefits of improved productivity through upgrading office quality.

Stallworth and Ward (1996) acknowledge the research undertaken in the 1930s by Mayo and Roethlisberger (Roethlisberger & Dickson, 1939) and the contribution they made in shifting the focus away from evaluating the work environment as a purely physical environment, and to one of perceiving the work environment as also being a social environment (Stallworth & Ward, 1996). However, Stallworth and Ward (1996) develop the debate by suggesting that the changing nature of the work setting has brought the physical environment back into prominence. This is a view supported in a literature review undertaken by Haynes *et al* (2000), who propose that the preoccupation with minimisation of space standards and cost reduction has developed in the literature, at the expense of viewing office space as a resource that can be used to achieve increased organisational performance.

Stallworth and Ward (1996) propose that the human element should be part of the debate with regards to office productivity and use a range of case study examples to support their ideas. They also suggest that research that links people, motivation, productivity and the work environment can best be summed up as "person-environment fit" (Stallworth & Ward, 1996).

> *"The existing data suggest that non-supportive design has negative effects on work and workers, and design appropriate to the work has positive ones. In fact, many businesses have begun changing their design and organizational cultures with positive results. Only time and more observation can reveal what will result from these changes."(Stallworth & Ward, 1996, p34)*

Stallworth and Ward (1996) acknowledge that the linkage between people and the physical environment is starting to be addressed by the emergence of environmental psychology, but they also acknowledge that this type of research is in its early stages of development.

> *"Research of relationship of office design and its effect on the workers' needs and satisfaction, especially regarding productivity, is still in its infancy." (Stallworth & Ward, 1996, p41)*

A totally "people-centred" approach to evaluating users of office environments is adopted by Leifer (1998). He uses a measure of office user satisfaction on a five-point Likert scale, and presents a number of Australian case studies as means of supporting this approach to user evaluation. However, other authors such as Hadi (1999) propose a more holistic view to the measurement of office productivity. She proposes that productivity measures should be discussed and split into three sections:

1. Quantifiable and tangible measures
2. Indirect measures, i.e. staff turnover etc
3. Organizational measures such as teamwork and creativity

Hadi's (1999) proposals do not establish what exactly would constitute as quantifiable and tangible measures, and how organizational measures, such as teamwork, would be measured. This is a view supported by Nachum (1999) who uses Swedish management consulting firms to illustrate the inappropriateness of the use of manufacturing based measures for assessing productivity of professional services firms (Nachum, 1999). This illustrates the point about the complex nature of measurement of office worker productivity.

Hadi (1999) then goes on to discuss the various methods that data can be collected.

> "Questionnaires, observational techniques, structured interviews, focus groups and job/task analysis." *(Hadi, 1999, p20)*

It could be argued that this is merely a list of research methods, rather than a justified methodology. The main proposal is that there is a requirement for a range of viewpoints to be considered when trying to assess productivity in the workplace.

> *"Without observation and physical measurements you will miss the objectivity, without a broad range of subjective opinions from all involved parties, through questionnaires, interviews and focus groups you will miss the balanced perspective needed to give you the big picture." (Hadi, 1999, p21)*

Whilst Hadi (1999) presents an argument for an assessment of both the tangible and intangible components of the office environment, which on the face of it appears to be a reasonable proposal however no research results are presented, and therefore the practicalities of adopting such a wide range of research methods cannot be evaluated.

The Office of Real Property, which is responsible for the US government offices, proposes a "holistic" view for office evaluation under the guise of "The Integrated Workplace" (Office of Real Property, 1999a). They claim the challenge facing "Corporate America" in the competitive marketplace is to use the workplace as a strategic tool to allow organisations to continually reinvent themselves. Whilst the Office of Real Property claims to offer an integrated solution, the claimed benefits to "Corporate America" tend to be cost benefits. The Office of Real Property use a number of supporting references for their case, i.e. potential staff productivity increases of 5-25% (Wyon, 1996), however the claims made, tend to be about quantity of output, a production focus, and less about the quality of output, which may be more relevant in an office which consists of knowledge workers.

The Office of Real Property develops their Cost per Person Model in the "Workplace Evaluation Study (Office of Real Property, 1999b). Whilst the emphasis is on the estimated savings available by the use of alternative work environments, there is an acknowledgement that office worker productivity is more complex than just measuring outputs.

> *"Traditional measures of real property performance concentrate on cost and ignore the benefit side of the equation. Underlying this one-sided view is the fact that the primary benefit we obtain from workplace advances and improvements would seem to be an increase in productivity. In the case of knowledge workers (a description that fits a large proportion of Federal workers housed in primarily office-type space), the question of how to measure productivity is just beginning to be studied." (Office of Real Property, 1999b, p21)*

Whilst the Office of Real Property (1999b, p24) acknowledge the complex nature of measuring productivity they maintain that any measurement is better than no measurement, and propose the following examples of indirect measurement of employee productivity:

I. Turnover – retention of employees, cost of retaining

II. Absenteeism – sick leave, annual leave

III. Self-assessment of workplace effects on one's own productivity

IV. Time-tracking devices –log books, overtime, project hours

V. Customer demand for products or services

VI. Observed downtime for modifications, complaints, interruptions

VII. Anecdotal evidence on workplace suitability – people's perceptions of workplaces suitability are still a viable measurement, especially when captured from "grassroots" perspective.

VIII. Churn costs – employee downtime, space move costs, time to execute a move and get a person back up-and-running (phone, computer, etc)

As in the proposals of the indirect measurement of productivity by Hadi (1999), the Office of Real Property (1999b) offer no numerical data to support the practical application of their proposed indirect productivity measures.

Clements-Croome (2000, p8) presents the following productivity measures, from an ASHRAE[7] workshop on "Indoor Quality" (1992), as being significant:

Table 2:1 Proposed measures of productivity from ASHRAE workshop on "Indoor Quality" (1992)

	Proposed measures of productivity
1	absence from work, or workstation
2	health costs including sick leave, accidents and injuries
3	Interruptions to work
4	controlled independent judgements of work quality
5	self-assessments of productivity
6	speed and accuracy of work
7	output from pre- existing work groups
8	cost for the product or service
9	exchanging output in response to graded reward
10	volunteer overtime
11	cycle time from initiation to completion of process
12	multiple measures at all organisational levels
13	visual measures of performance, health and well-being at work
14	development of measures and patterns of change over time

Oseland (1999) included the measures from the ASHRAE workshop in his extensive literature review, and identified that little to no research had been undertaken using such measures. He proposed that many of the items on the list tended to be performance indicators, rather than measures of productivity. Oseland (1999) establishes three different approaches to measuring productivity.

i) Performance measures,

ii) Self-assessed productivity, and

iii) Staff costs and profit.

When exploring performance measures Oseland (1999) uses a range of literature to illustrate the attempts made to develop performance measures to quantify productivity. If anything this review illustrates the lack of agreement as to what constitutes a productivity measure. Oseland (1999) raises an interesting point with regards to reducing staff turnover, by proposing that a good working environment could retain staff, in cost terms this could be seen as an improvement of productivity, since recruitment and training costs can be more than one years salary in a blue chip company. An additional benefit of a good working environment

[7] American Society of Heating, Refrigerating and Air-Conditioning Engineers

is that it may also attract new members of staff; this in itself may increase productivity by the introduction of new ideas. Whilst Oseland (1999) does not establish definitive performance measures, he reiterates the complexity in establishing tangible measures of office productivity, he also acknowledges the difficulty in measuring the service sector, since the outputs tend to be ill defined and prone to a wide range of variation. This point is probably best illustrated by a quote Oseland used from Brill *et al* (1984) after a survey of 70 companies.

> *"No organisation in our survey has available any in place work measuring system for measuring job performance."(Brill et al, 1984)*

It is this complex nature of trying to define quantifiable productivity measures appropriate to the office environment, that leaves the whole area of office productivity measurement as being ill defined, and void of any robust and valid office productivity measurement framework.

Having acknowledged the weakness of trying to establish more tangible means of assessing productivity, Oseland (1999) reviews the self-assessed approach to productivity. He proposes that self-assessment of productivity is not a new measure, and goes on to argue that perceived productivity could be as important as actual productivity.

> *"Self-assessment of productivity has been used in the field for some time and has provided useful results." (Oseland, 1999, p4)*

Whilst Oseland (1999) presents evidence to support the notion that perceived productivity can be used as a surrogate for actual productivity, he also acknowledges that it can be useful in assessing relative changes in performance. Oseland (1999) stops short of confirming self-assessment as the most appropriate measure of office productivity, and goes on to request further research with a larger sample sizes to instil confidence in the self-assessment measure.

Leaman and Bordass (2000) acknowledge that it is impossible to establish a meaningful productivity measure for all office occupants, and therefore propose that perceived productivity, rather than actual productivity, be used as a surrogate measure (Leaman & Bordass, 2000). They go on to discuss the advantages and disadvantages of using a self assessed measure of productivity, and conclude on balance the advantages outweigh the disadvantages.

The advantages and disadvantages of using a perceived productivity scale, as identified by Leaman and Bordass (2000, p170), are presented below:

Advantages:

- A single productivity question covers the topic so it can be incorporated in surveys with wider objectives. (Although building managers are still wary of the questions and sometimes forbid its use)
- The question is common to all respondents so that fair comparisons can be made between most of them.
- It can be incorporated in questionnaires across different building types.
- Large samples may be surveyed relatively cheaply.
- Benchmarks of averages or medians may be used to assess how occupants' perceptions in individual buildings score against a complete dataset.
- Data analysis and verification are easier across large samples in many different buildings.

Disadvantages:

- The nagging doubt that perceived productivity as measured may not associate well with the actual productivity of occupants. (Although many agree on the key point that perceived and actual productivity are strongly associated)
- The need for occupants to judge their own reference point when answering the question (they sometimes want to know productivity with respect to what?)
- The possible effects of context and other ruling factors at the time of the survey, for example, rumours of possible redundancies.

It could be observed that one of the advantages claimed by Leaman and Bordass (2000) i.e. perceived productivity measured by a single question, could be perceived as a weakness and could be improved upon by the use of a multi-variable approach.[8]

It could be concluded that the difficulties in measuring office productivity, generally stem from the lack of any universally accepted means of assessing job performance. The range of different tasks undertaken in the office environment, adds to the complexity of measurement. It is therefore understandable that research that has produced evidence has adopted a pragmatic self-assessment approach. This approach to measurement adopts a "people-centred" approach to office evaluation, which is in alignment with establishing the end user or occupier perspective.

2.2.4 Cost reduction to human contribution

This section will aim to establish that the quest for productivity improvements has led to two different paradigms, the control paradigm and the enabling paradigm. The control paradigm aims to improve productivity through greater efficiency, which when applied in practice usually means a reduction in resources, which can be either financial or actual space. The enabling paradigm acknowledges the human asset and the creation of knowledge capital as a means of improving office productivity.

When discussing staff cost and profit Oseland (1999) argues that staff salaries are a convenient means of assessing productivity, since anything that affects staff time, such as illness, can be converted into a financial measure. Oseland (1999) develops the staff cost debate by comparing it to premises revenue costs, suggesting that staff cost can be in the region of 70-80% of revenue, whilst premises costs can be a low as 5% of revenue. The argument is developed to suggest that small gains in staff productivity can offset capital costs for premises development, such as heating, ventilation and air conditioning. This leveraging approach can be argued the opposite way, mismatching people with their work environments could have a significant impact on overall organisation performance.

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[8] This perceived weakness is something that will be addressed and developed further in chapter 3.

The same "leveraging " argument is adopted by Clements-Croome (2000) to establish that a greater emphasis should be placed on productivity improvements of indoor environments, rather than energy efficiency of the offices. This approach has further been developed by Becker and Pearce (2003), who propose an integrated cost model. The model consists of both corporate real estate and human resource factors. They call their model the Cornell Balanced Real Estate Assessment model, COBRA, which includes the three main variables: measures of productivity, human resources costs and real estate costs. Together the three variables in the model enable organisations to make strategic real estate decisions.

> *"HR impacts can be highly significant, and if incorporated into a single model might lead to recommendations very different from those based only on the direct real estate costs." (Becker & Pearce, 2003, p233)*

A typical example would be the evaluation of a new capital build, if the choice was between a basic development or one of a higher standard, and subsequent cost, the costing model would predict the appropriate rise in employee productivity required to pay for the more expensive option. Although this raises the issue of productivity measurement to the strategic level, thereby allowing organisations to make informed decisions by identifying the potential consequences of their decision on productivity, the productivity measure used is determined from the increase in turnover, and is therefore not a direct measure of individual productivity. It could also be argued that since the productivity measure is not derived from the individual level, then the model could potentially be used as a cost reduction model since the true impact on individual productivity is not incorporated.

Wrennall (1999) offers support to Oseland's (1999) proposal to move the debate about office performance away from cost reduction, and more towards staff performance. Wrennall (1999) goes further by calling for the creation of a new "productivity scientist", whose purpose would be to look beyond cost reduction methods, and more towards how office environments can add value to organisations. The main proposal presented by Wrennall (1999), is that the central emphasis of organisations should be to acknowledge that they could profit from the knowledge capital of their employees. This proposal is significant in that it clearly acknowledges the value of employees in the creation of knowledge capital. Wrennall (1999) proposes that maximum productivity gains can be made when organisations put into place strategies to ensure that knowledge is explicit rather than implicit through employees working together sharing their knowledge.

The productivity measurement debate is developed by Clements-Croome & Kaluarachchi (2000), who propose that a responsive working environment should create a sense of well-being. They propose that productivity is dependent on "healthy buildings", and therefore widen the debate about productivity measurement to incorporate health, well-being and comfort. They propose a five level analytical hierarchy process model to represent the main factors that influence productivity. The model contains environmental factors such as temperature and humidity, ventilation, lighting, crowding and then links them to health factors which are defined as respiratory, skin, nervous, nasal and related problems. Whilst this model contributes to the measurement of environmental and comfort components associated with productivity, it lacks the social and behavioural components that are an integral part of a modern office.

The main weakness of the analytical hierarchy process model, proposed by Clements-Croome & Kaluarachchi, (2000), is addressed by Clements-Croome (2000) by the inclusion of a social concept as being a factor which has an affect on productivity. Although this proposal lacks the operationalization of the concepts to actual measures, it does provide a theoretical framework for considering productivity measurement, which has been previously lacking.

Table 2:2 Factors that affect productivity (Clements-Croome, 2000, p11)

Factors which affect productivity	
Personal	Career achievement home/work interface intrinsic to job
Social	Relationship with others
Organisational	Managerial role, organisational structure
Environment	Indoor climate, workplace, Indoor Air Quality

It could be argued that the only concept that the property or facilities manager can control would be the environment component. However, with the growing requirement for office environments to be more knowledge exchange centres, there is a challenge facing office designers which is; can they create office environments that enable greater knowledge sharing and interaction, thus making the social factor an integral consideration for the modern office.[9] Price (2001) recognises the limitations of current research and developments in working environments by establishing a need to address the psychological needs of individuals.

It could be argued that a limitation of the office productivity literature is that the linkage between individual productivity and the wider impacts on business are not made (Haynes *et al*, 2000). This appears to be mirrored by a more general limitation of linking facilities performance measures to the business performance measures (Hinks, 2000). This is a view supported by Bradley (2002). Having reviewed 150 sources relating to workplace performance improvement he concluded that:

> *"There are two primary shortcomings in the literature searched. Firstly, it is apparent that real estate and workplace design research, the subject of programming and evaluating performance change is rarely approached systematically and holistically in relation to business performance.*
>
> *Secondly the scope of performance study is often drawn so narrowly (e.g. task productivity resulting in improved comfort conditions) that the output is unconvincing and of little strategic importance to business leaders." (Bradley, 2002, p151)*

Bradley (2002) is critical of the academic literature, claiming that:

> *"Practitioners and managers do not value the academically rigorous focus on a single dimension of performance." (Bradley, 2002, p151)*

In an attempt to offer a more holistic approach to real estate and business performance Bradley (2002) proposes Kaplan and Norton's "balanced scorecard" techniques (Kaplan & Norton, 1993). The four major components of the scorecard are: financial, customer, internal business process and organisational development (innovation and learning). Bradley (2002) proposes that the business measures that can be derived from the balanced scorecard, and are specific to real estate and workplace, are as follows:

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[9] This challenge is not only levelled at office designers, but also office productivity researchers, i.e. can the social or behavioural components that affect productivity be operationalised?

1. Stakeholder perception (e.g. customer satisfaction and loyalty, community sentiment)

2. Financial health (e.g. economic or marker value added)

3. Organisational development (e.g. innovation quality and quantity; cultural factors; team formation; and new process introduction rate)

4. Productivity (e.g. space utilisation, process speed and quality, waste levels)

5. Environmental responsibility (including transport-related sustainability effects)

Plus of course:

6. Cost efficiency (e.g. total occupancy cost related to revenue generation).

Whilst Bradley (2002) attempts to present a business model, the language used for the productivity elements appears to be clearly planted in the cost reduction paradigm, rather than the more appropriate value added paradigm. It should also be acknowledged that the proposal by Bradley (2002) is more of a theoretical framework, as no empirical evidence is presented to support the balanced scorecard approach. However, he identifies the limitations of perceiving workplace innovation, and consequent evaluation, as being a one-off project, rather than being integrated into a more complete change management programme, a view supported by Laframboise *et al* (2003). The proposal being that evaluation should be undertaken on a continual basis and be built into, and budgeted for, within project plans. Bradley (2002) ultimately concludes with the following:

> *"Relative indications of performance (monitored over a relevant time period) are likely to be more useful in judging the success of workplace innovation than absolute metrics." (Bradley, 2002, p15)*

The benefits of continual evaluation of workplace environments are supported by Kaczmarczyk & Murtough (2002). However they warn against the use of evaluations as a means to create a case for innovative workplace environments. McKee (2003) states that any tools used for productivity improvement should be deployed in a structured framework that manages the overall change process.

The inclusion of office evaluation into the change management process requires that the traditional measurement paradigm of measuring space needs to be challenged. A more broader definition of office space needs to be established, to capture the purpose of the office space. Kaczmarczyk & Murtough (2002) acknowledge such concepts as "human capital" and "knowledge workers" and argue that to create high performing and sustainable environments, there needs to be a shift in focus from "place" to "workplace".

> *"The workplace concept represents the convergence of three disciplines: Facilities management, information technology and human resources." (Kaczmarczyk & Murtough, 2002, p163)*

Kaczmarczyk & Murtough (2002) acknowledge that the inclusion of human resources and information technology may be unfamiliar areas for people trained in real estate or facilities, but if a new measurement paradigm is to be established then ways of evaluating these components needs to be created. Three new ways of evaluating the workplace are proposed:

I. General Services Administration (GSA) Cost per Person Model

II. Employee satisfaction with the workplace

III. Productivity Payback Model

The GSA Cost Model, which has been reviewed previously, attempts to include areas of measurement beyond the traditional office space, but it converts these areas purely into cost (Office of Real Property, 1999b) This approach lacks the value added components of offices, such as office space as a knowledge exchange centre.

The second new way of evaluating the workplace attempts to evaluate employee satisfaction with their workplace, and a conceptual Workplace Performance Model is proposed (Kaczmarczyk & Murtough, 2002, p 168):

> *"The workplace can be broadly subdivided into three major components: People, Places and Tools.*
>
> *A high-performing workplace is defined by three measures:*
>
> *1) Employee satisfaction (people like their environment)*
>
> *2) Productivity (people can be at their most productive in the environment)*
>
> *3) Employee retention (people stay with the organisation in part because they like their environment)"*

Whilst an attempt is made to support their Workplace Performance Model, by stating that a survey of 200 people was undertaken across a range of private sector and public sector organisations in the US, Canada and the UK, none of the results are actually presented. Also whilst the productivity element was established as being an integral part of the Workplace Model, no explanation as to how it was measured is presented.

The third method of evaluating new workplaces proposed was the Productivity Payback Model. With this model Kaczmarczyk & Murtough (2002) acknowledge the complexity of measuring the productivity of knowledge workers, and therefore attempt to incorporate the concept of productivity into a broader analytical framework, the result being the Productivity Payback Model (PPM). The PPM is based on the premise that when investments are made in new working environments, it is actually the people that are being invested in, and not the facility. This is similar to the Cornell Balanced Real Estate Assessment model proposed by Becker & Pearce (2003), and is more of a predictive productivity indicator rather than a productivity measure. The purpose of using a predictive productivity indicator is to demonstrate the benefits of a new office environment, thereby justifying the capital expenditure (Becker & Pearce, 2003).

PPM asks two questions to evaluate if investment should be made into new environments (Kaczmarczyk & Murtough, 2002, p 171):

> i) How much must productivity of the employees increase to offset (more precisely, to payback on one year) the workplace investment?
>
> ii) How confident are we that the required productivity increase can be achieved?

The first question assumes that the employee's contribution to the organisation can be defined in very specific revenue terms, which is an issue that becomes more complex for knowledge workers. To evaluate the second question Kaczmarczyk & Murtough (2002) propose the use of a matrix, as a look up table, of published studies that claim they have measured productivity increases through the creation of new workplace environments. Since there is no uniformly accepted way of measuring productivity, then by definition the range of studies claiming to have measured productivity are going to present contrasting results. Finally since there is no proposed means of measuring productivity, new environments cannot be revisited after the investment to establish if productivity has actually increased, thereby ultimately the loop cannot be closed.

If the debate about office productivity is to move away from, and beyond, the traditional cost cutting methods, then greater emphasis needs to be placed on understanding offices from the occupier perspective (Fleming, 2004). This approach is supported by Oseland and Bartlett (1999) in their book *"Improving Office Productivity: A guide for business and facilities managers"*

> *"The purpose of this guide is to increase the productivity of organisations by enhancing the output performance of their staff. This is a fundamental departure from the traditional strategy for office productivity which focuses on cutting input costs with little or no regard to the impact on staff performance." (Oseland & Bartlett, 1999, pxiii)*

To increase understanding of staff performance there is a requirement to view offices as dynamic complex environments, which enable and support the work patterns of their occupants. This requires greater consideration to be given to the behavioural patterns of office occupiers.

Mawson (2002) claims that, from the research undertaken over the years, there is little doubt that the working environments have an impact on the occupiers' productivity. However, establishing a quantitative measure of the impact has proved to be more difficult. He develops the occupier perspective approach, by proposing that the two major causes of productivity loss in offices are caused by:

i) Distractions

ii) Mismatch between the occupiers work activities and the work environment provided.

Distractions are defined as:

> *"Anything that takes attention away from the task to be performed. Distraction emanates from unexpected stimuli, which can take the form of noise, visual disturbance (e.g. glare or movement) or being too hot or too cold. It can also stem from the failure of services and systems (e.g. equipment or networks) that inhibit tasks from being performed effectively." (Mawson, 2002, p 3)*

This definition is wide ranging, but tends to concentrate on the physical and technical components of the working environment, and therefore lacks the behavioural component. However, Mawson (2002) acknowledges that distractions may not always have a negative effect on performance, stating that for some people an element of distraction, i.e. background music, may actually aid concentration. Having acknowledged that distractions can be beneficial for some people, he goes on to propose that a distraction free working environment is more productive than an environment that has a number of distractions throughout the day.

> *"Seventy minutes of productivity is lost in a typical eight-hour day as a result of distraction." (Mawson, 2002, p4)*

It is proposed that 15% of the working day is lost productivity caused by general conversations. This approach appears to suggest that only constant work is productive work, and that general conversation, i.e. the social environment, has a negative effect on occupiers' productivity. Both these stances appear to support the 'old' Taylorist management paradigm that office workers should have their heads down, and be concentrating on tasks and outputs. Also this approach does not appear to value the chance conversation, which could allow the creation and transfer of knowledge and new ideas.

The preoccupation with distraction free work tends to marginalize the benefits of interaction through conversation in the modern office (Price and Shaw, 1998). This is an area that requires further development, and will ultimately form the basis of this thesis.

The second major cause of productivity loss, as identified by Mawson (2002), is place mismatch. This is when the office environment does not support the work process undertaken in that environment. It is therefore proposed, that a mix of workplace settings and services be provided as enablers, so that people can provide their best performance.

> *"However to get to this point requires examining the way individuals, teams and organisations work, both in a physical context as well as in an information and knowledge context." (Mawson, 2002, p7)*

Although Mawson (2002) identifies the need to establish office occupier's work processes, so that they can be matched against their environments, no method of categorising work processes is suggested. The concept of evaluating the match between the work process and the environment is an important one, and will be developed further in this thesis.

Van Ree (2002, p357) attempts to summarise the debate about the impact of office accommodation on organisational performance by stating that fundamentally their are two main approaches to contribute to organisational performance:

i) Achieving greater efficiency by reducing the occupancy costs by reducing the amount of space per employee; and

ii) Achieving greater effectiveness by improving the productivity of the employees by providing a comfortable and satisfying working environment.

The first has probably been the prevailing paradigm for most real estate and facilities managers with regards to justification of office refurbishments (Haynes *et al*, 2000). However, this thesis will propose that it is the second approach where the debate about productivity improvements should be centred.

2.2.5 Summary

The purpose of the office environment has changed over the last century, from that of one which houses occupiers undertaking standard processes, to one that houses a range of different work patterns. The initial assumption, that office workers adopt simple repetitive tasks, led to early office designs being based on the scientific management principles of Frederick Taylor.

However, subsequent evaluations have revealed the office environment to be more complex, with the productivity of its occupants being dependent not only on the physical environment, but also the social environment. The addition of the social context has subsequently meant that the definition as to what constitutes office productivity has remained ill defined.

The lack of a clear definition of office productivity has subsequently meant that a range of different approaches, and metrics of measurement, has been adopted. Whilst no one approach has gained universal acceptance, it is clear that the self-assessed measure of productivity is better than no measure of productivity.

Finally, the debate about office productivity improvement can be summarised by two main approaches. The first adopts a greater efficiency approach, and centres on reductions in either cost or space provision. The second adopts a greater effectiveness approach, and centres on occupiers being provided with an office environment that enables them to increase their productivity.

Whilst this section has aimed to maintain a strategic overview of the office productivity debate, it is clear that two main bodies of research have emerged. The first body attempts to link the physical office environment with productivity, and the second body attempts to develop a link between the behavioural environment and productivity. The next section will review the physical environment literature, and the subsequent section will review the behavioural literature.

2.3 Physical Environment

This section aims to review the literature that claims to link the comfort and the layout of the office environment to the productivity of its occupants. Whilst the general concept of comfort will be addressed, specific attention will be given to the air quality, sick building syndrome and lighting. The office layout discussion will include the open-plan versus cellular office debate, and also the matching of the office environment to different work patterns.

2.3.1 Comfort

Office evaluations have traditionally been Post Occupancy Evaluation (POE) surveys that assess how satisfied occupiers are with their working environments (McDougall *et al*, 2002). However, whilst this form of survey establishes an assessment of the quality of environment, it does not establish if the environment affects the occupiers' productivity. Leaman (1990) presented the idea that a possible relationship exists between the quality of the office environment and the productivity of its occupiers. Subsequently, Leaman (1995) adopted a survey method, in an attempt to establish if the occupiers who were dissatisfied with their indoor environmental conditions were also less productive in their work. He concluded that:

> *"People who are unhappy with temperature, air quality, lighting and noise conditions in their offices are more likely to say that this affects their productivity at work." (Leaman, 1995)*

The questionnaire adopted consisted of eight main sections.

Table 2:3 Survey questions (Leaman ,1995)

Survey Questions	
Environmental Comfort	36 questions
Health Symptoms	10 questions
Satisfaction with amenities	5-15 questions
Time spent in building	1 question
Time spent at task	1 question
Productivity	1-3 questions
Perceived control	5 questions
Background data	3-10 questions

The measure of productivity was achieved by adopting a self-reported measure, presented in a nine-point scale ranging from <-40% to >+ 40% (loss/gain), based on the question:

> *"Does your office environment affect your productivity at work? "(Leaman, 1995)*

Leaman (1995) suggests that a correlation exists ($r = 0.92$), between people who report dissatisfaction with their indoor environment and those that report the office environment to be affecting their productivity; and the finding is reported to be significant ($p = 0.0034$). However, Leaman (1995) acknowledges that no statistical association exists between self-reported productivity and satisfaction with the office environmental conditions. These results must be interpreted with care, as correlation between variables does not prove causality. Moreover, the self–reported productivity measure adopted only consists of a single question.

Whereas Leaman (1995) could only offer support of a relationship between dissatisfaction and productivity, Oseland & Bartlett (1999) evaluated occupiers across ten office buildings and reported a correlation between productivity and satisfaction ($0.93< r <0.99$). They acknowledge that the high correlation could be partly explained by the way the questions were asked:

> *"Considering the effect on your performance, how satisfied are you with the office facilities and services?" (Oseland & Bartlett, 1999, p92)*

One of the key findings from Leaman's (1995) analysis is that people's perception of their ability to control their own working environment is reported as being an important element of their productivity. This is a result supported by Oseland & Bartlett (1999), claiming that a good correlation exists between perceived control over environmental conditions and productivity (r = 0.49).

An interesting concept put forward by Leaman (1995), with graphical evidence, is "forgiveness". This relates to how forgiving the occupants are of the shortcomings of the building. It is proposed that "forgiveness" can be increased if the occupants:

> *"Know that every effort is made to overcome them, and they will usually tolerate problems which they understand are hard to solve" (Leaman, 1995, p150)*

Establishing the factors that should be included when assessing the office environment is a complex area, although Oseland (1999) concluded, having undertaken an extensive literature review, that occupiers' satisfaction with their environment, i.e. how comfortable they were, was instrumental in their productivity levels. Oseland (1999) establishes that comfort with the environment includes both physiological and psychological components as well as the physical environmental conditions.[10]

Table 2:4 Components of environmental satisfaction (Oseland, 1999)

	Environmental Satisfaction (Comfort)
Environmental Conditions	Physical Conditions, Space, Ergonomics, Aesthetics
Physiology	Gender, Age, Ethnic Group
Psychology	Personality, Expectations, Experience, etc

Although Oseland (1999) acknowledges the role of physiological and psychological components in office occupiers productivity, the review largely concentrates on the environmental conditions of the office environment, which are broken down as follows:

[10] It should be noted that Oseland (1999) actually proposes a broader theoretical framework for the evaluation of performance and productivity. He includes the concepts of job satisfaction and motivation. However this analysis will concentrate on the environmental components.

Table 2:5 Elements of environmental conditions (Oseland, 1999)

	Environmental Conditions
Physical Conditions	Temperature, Light, Noise, air quality etc
Space	Plan, Layout, Privacy
Ergonomics	Work-station, Controls
Aesthetics	Colour, Quality

The breaking down of the environmental conditions into four dimensions is a useful way of considering operationalizing the concept of the physical environment. Although it could be argued, that the behavioural component of the office environment is not identified.

The debate about the use of occupier satisfaction as a surrogate measure to office productivity has been developed by Fitch (2004). He adds to the debate with an evaluation of serviced office environments, and claims that a relationship exists between satisfaction with the office environment and the reported productivity levels of the office occupiers (Fitch, 2004). Clark *et al* (2004) attempt to present a unifying model, that links building performance, user satisfaction and self-reported productivity techniques. As a general model communalities exit between the three areas, however on a detailed level the different techniques provided specific detail that would have been lost in a totally unified model of evaluation (Clark *et al,* 2004), and therefore demonstrates the benefits of different approaches. The challenge to find a validated method of measuring and reporting office productivity remains to be achieved, with some authors referring to this area of research as the *"search for the Holy Grail"* (Mawson, 2002).

Leaman & Bordass (2000), in their seminal work, aim to address the question "*What features of workplaces under the control of designers and managers significantly influence human productivity*". This is an appropriate stance as it puts delimitations on the research, concentrating on areas that can be directly affected by designers or facilities managers, and therefore does not attempt to address issues such as stress, management attitudes and job satisfaction. In this work Leaman & Bordass (2000) use the term "killer" variables, which is defined as a variable having *" critical influence on the overall behaviour of a system"*, p171. The "killer" variables are arranged into four clusters.

The clusters are:

i) Personal Control

ii) Responsiveness

iii) Building Depth

iv) Work Groups

Leaman & Bordass (2000) present results from 11 UK buildings, and claim that seven out of the 11 buildings had a significant association between self-assessed productivity and perception of control. Leaman & Bordass (2000) develop this claim by stating that in their research the lack of environmental control is the single most important concern of office occupiers.

The responsiveness dimension relates to how quickly the facilities management team can respond to a complaint about their environment. This probably links back to Leaman's earlier work, which established the "forgiving" nature of people, if they were kept informed of events relating to their environmental comfort (Leaman, 1995).

Leaman & Bordass (2000) present evidence that air-conditioned buildings (usually, but not always deeper than 15m, have a more negative effect on perceived productivity than naturally ventilated buildings (i.e. less than 15 m across). The connection is made between increased dependency on environmental systems, such as air-conditioning, and ill health symptoms.

In evaluating the fourth cluster of variables, which relates to workgroups, Leaman & Bordass (2000) acknowledge that they have only been able to get both productivity and workgroup data on rare occasions. However they maintain:

> *"That perceptions of productivity are higher in smaller more integrated workgroups"(Leaman & Bordass, 2000, p183)*

Other researchers have proposed that a relationship exists between the number of people working together, and their corresponding productivity levels (Olson, 2002; Fitch, 2004). Olson (2002) ultimately concludes that productivity improvements can be achieved by moving away from open-plan environments, and back to more private cellular type offices.

Leaman & Bordass (2000) concludes that offices work best for human productivity when:

i) There are opportunities for personal control

ii) There is a rapid response to environmental issues

iii) There are shallow plan forms, preferably with less technical and management-intensive systems

iv) Activities that properly fit the services, which are supposed to support them

Support for improved facilities management, as a means of increasing office productivity, is presented by Clements-Croome (2003). He maintains that both greater energy savings and increases in productivity can be achieved by ensuring that healthy buildings are produced. He also acknowledges that it is not just the design and construction of the building, but also the way the building is run, i.e. the facilities management, that can impact on occupier productivity. Clements-Croome, (2003) identifies that the most frequent complaints relate to thermal problems, stuffiness, sick building syndrome and crowding. It is therefore suggested that by improving the office environmental conditions, occupier productivity could be increased by 4-10%

The Office Productivity Network (OPN) assesses office productivity with two occupant feedback tools. The tools proposed are the *OPN Survey* and the *OPN Index* (Oseland, 2004). The OPN survey is a questionnaire that can be administered in both paper and web based formats. Oseland (2004) claims to have administered the questionnaire in 60 buildings and has over 6,500 responses.[11] Whilst the office occupiers complete the *OPN Survey*, the data collected for the

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[11] The size of this database would make it probably one of the largest that relates to occupier productivity.

OPN Index is established by interview with selected staff using an interview pro-forma, since knowledge of the building design and operation is required[12].

The *OPN Survey* consists of a number of sections and can be seen below (Oseland, 2004, p2):

- Satisfaction with Facilities - 19 questions enquiring whether the respondents are satisfied with how the various design and operational factors (e.g. workspace, meeting areas, technology) support their work activities; note that although the question asks the respondents to rate their satisfaction, the emphasis is actually on supporting work activities which relate to productivity;

- Satisfaction with Environment - 15 questions asking whether the respondents are satisfied with how the environmental conditions (e.g. temperature, noise, privacy) support their work activities;

- Importance - 2 questions which ask the respondents to identify which of the facilities and environmental conditions they consider the most important to "get right" so that they can work well;

- Self-assessed Productivity - 2 questions, which ask respondents to estimate the impact of the facilities and environment on their productivity;

- Downtime - 18 questions which ask the respondents to estimate the amount of time per week wasted due to a range of poor design and operational issues; these questions were developed as a direct result of feedback during the focus groups;

- Satisfaction with Work Activities - 11 questions asking whether the facilities and environment support various work activities (e.g. quiet work, teamwork, meeting deadlines);

- Work Duties - 12 questions to estimate the time spent carrying out the various work activities (e.g. PC work, telephone usage, formal meetings);

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[12] Oseland (2004) claims to have data for 20 buildings using the *OPN Index*.

- Work Time - 7 questions to estimate the time spent working in and out of the office;

- Background Details - Questions to identify sub-groups whose responses to the above questions may be compared (e.g. grade, location in building, business unit).

Oseland (2004) includes two questions specifically relating to productivity. One relates to the facilities and productivity, and the other relates to the environment and productivity. Oseland (2004) adopts the same nine-point scale for self-assessment of productivity as Leaman (1995) and Leaman & Bordass (2000). However in contrast to Leaman (1995) and Leaman & Bordass (2000), Oseland (2004) evaluates the facilities as well as the environment. It could be argued that this is an improvement in measuring productivity, i.e. from one question on productivity to two questions, although it does not allow the subcomponent of facilities and environment to be evaluated with regards to productivity. In analysing the data Oseland (2004) proposes, using a multiple regression analysis (weighted means), that change in productivity and overall satisfaction with the environment and facilities are highly correlated, i.e. facilities ($r = 0.94$) and environment ($r = 0.91$).

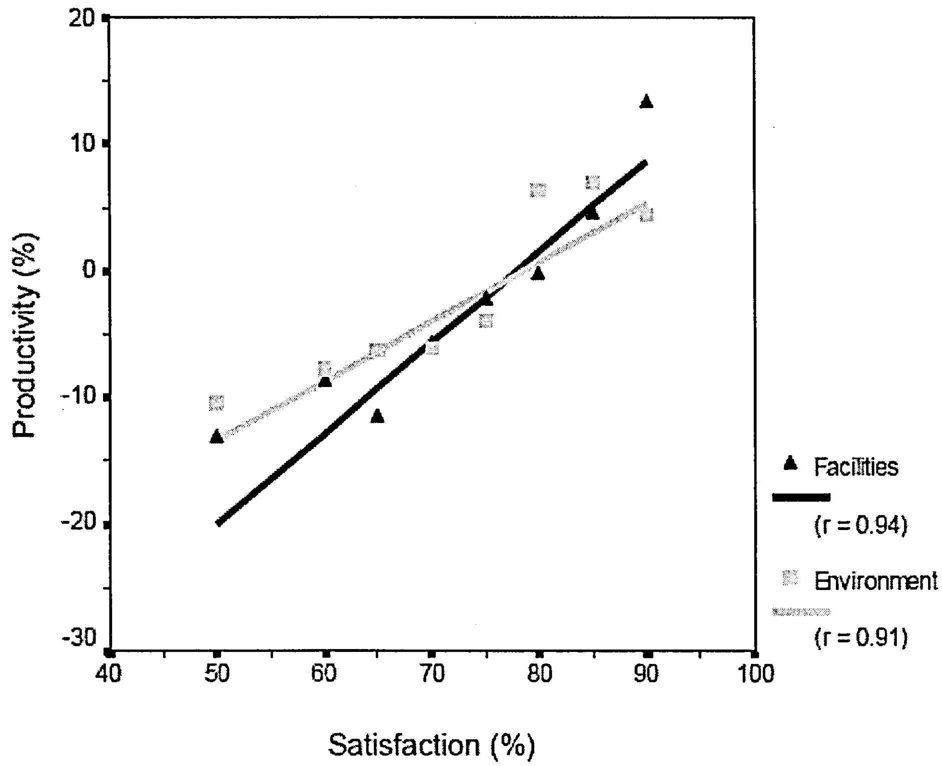

Figure 2.2 Correlation between productivity and satisfaction (Oseland, 2004)

The concept downtime is introduced and defined as effectively time wasted due to poor design and management of the office environment. Oseland (2004) presents evidence to suggest that correlations between downtime and satisfaction with the environment and facilities, i.e. facilities (r = 0.69) and environment (r = 0.78). Some of the downtime elements defined by Oseland (2004), i.e. waiting for lifts, walking between buildings, interruptions, waiting at fax & copier machines, could actually be opportunities for ad hoc conversations and knowledge transfer (Haynes & Price, 2004).

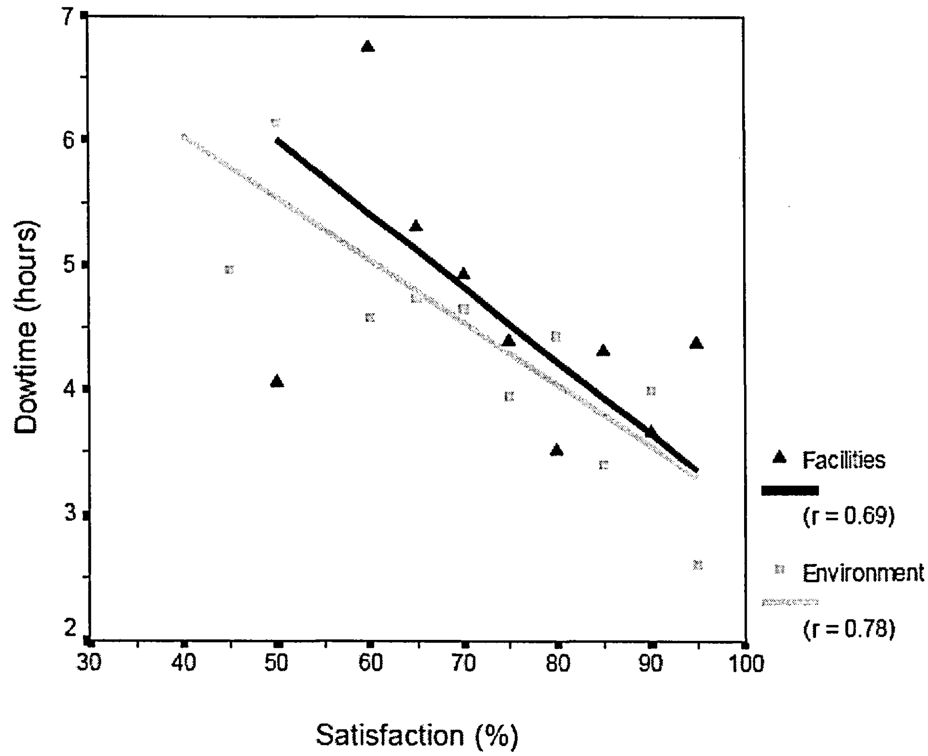

Figure 2.3 Correlation between downtime and satisfaction (Oseland, 2004)

The conclusions that Oseland (2004) draws from the analysis of the database, is that office occupiers are mainly dissatisfied with temperature and ventilation, commonly called the "hygiene factors". An explanation offered for this is the requirement for more individual control, an issue previously acknowledged by Leaman & Bordass (2000). Also since the results evaluated are largely from open-plan offices, it could also be concluded that the disadvantages of open-plan environment are not totally being addressed (Oseland, 2004).

Finally, Oseland (2004) concludes that:

> *"The environmental conditions which are considered most important to "get right" to support the respondents' work activities are: winter and summer temperature, ventilation, people noise, privacy and daylight" (Oseland, 2004)*

Roelofsen (2002) drew similar conclusions as Oseland (2004) having undertaken a review of the literature pertaining to the impact of office environments on employee performance. He concluded that in the office environment it was the thermal environment (temperature) and the air quality (ventilation) that had the most influence on people's productivity   Roelofsen (2002) calls for a validated unifying human model, which allows the concept of comfort, i.e. temperature and air quality, to be evaluated in terms of loss of productivity.

Whilst authors such as Oseland (2004), and Leaman & Bordass (2000), have attempted to evaluate occupier satisfaction against a range of environmental and facility issues; other authors have attempted to restrict their evaluation to one specific component and its affect on productivity. The next sections will review these specific pieces of research.

Air Quality

Dorgan & Dorgan (2000) argue that, due the to the amount of time that employees spend in their offices, it is important to ensure that the indoor environment is of an appropriate quality. They propose that a linkage exists between the quality of the environment and the health and productivity of the occupants. They attempt to establish the appropriate components of the environment.

> *"The indoor environmental quality (IEQ) is composed of factors such as space, temperature, humidity, noise, lighting, interior design and layout, building envelope, and structural systems. A subset of the IEQ is indoor air quality (IAQ). The factors that define IAQ are temperature, humidity, room air motion and contaminants." (Dorgan & Dorgan, 2000, p107)*

Dorgan and Dorgan (2000) maintain that if the Indoor Air Quality (IAQ) is not at the right level, then there will be an impact on the occupant's health and productivity. They base their proposals on two studies, funded by the National Contractors' Association, which investigated the health costs and productivity benefits of Improved Air Quality. The original study was under taken in 1993, and was further developed in 1995. It should be acknowledged that the studies undertaken were literature reviews of previous research that attempted to link IAQ and productivity. Ultimately, Dorgan and Dorgan (2000) conclude their review by establishing the lack of validated evidence, and called for further research, in the form of case studies, to establish the effects of improved HVAC systems on occupier's health and productivity.

In an attempt to quantify the effect IAQ has on productivity Wargocki *et al* (2000) adopted a traditional experimental approach to three independent studies including 90 subjects. The change of air quality was established by interventions, and the effects on the occupiers were assessed using a perceived air quality acceptability scale. The productivity measures adopted were measurable, i.e. not self-reported, since the activities undertaken in the office were simulated office tasks such as typing, addition and proof-reading. Wargocki *et al* (2000) concluded that a relationship exits between good air quality and office productivity.

> *" It confirms that good air quality improves the performance of text typing (P=0.0002), and a similar tendency is seen for addition (P=0.056) and proof-reading (P=0.087). A positive correlation between the air quality, as it is perceived by occupants, and the performance of typing (R2=0.82, P=0.005), addition (R2=0.52, P=0.07) and proof-reading (R2=0.70, P=0.08)." (Wargocki et al, 2000, p635)*

It could be argued that one limitation of the results presented by Wargocki *et al* (2000), is that they only relate to repetitive tasks, such as typing, addition and proof-reading. However, as previously argued, if offices are to be places of knowledge exchange, with people constantly moving around, the issue of providing appropriate IAQ becomes a more complex issue (Laing *et al*, 1998).

Health: Sick Building Syndrome

An attempt to broaden the debate with regards to office evaluation was undertaken by Whitley, *et al* (1996). They proposed that occupier's satisfaction with the indoor environment could be influenced by the climate of the organisation and the occupier's satisfaction with their job. Their research aimed to investigate Sick Building Syndrome, and its effects on occupiers, both in terms of health and productivity. They collected over 400 responses from two buildings. An occupational and organisational psychology questionnaire was adopted to assess job satisfaction, organisational climate and job characteristics. The environmental satisfaction was assessed using a seven-point user perception scale. Productivity was self-reported, using a perceived productivity scale. It is interesting to note that the self-assessed productivity scale adopted, with slight modification, was the same one originally proposed by Leaman (1995) and subsequently adopted by Oseland (1999 &2004).

Whitley *et al* (1996) concluded that:

> *"Office satisfaction is significantly associated with self-reported productivity (r=-0.42, p< 0.001)." (Whitely et al, 1996)*

Whilst this research adds to the debate by acknowledging that the office environment is more than just the physical comfort elements, and alludes to a behavioural environment which links to organisational culture, the limitations of the research must be acknowledged. Firstly the research was undertaken between two buildings in the same organisation, therefore the possibility of generalisation is reduced, and secondly the measure of productivity adopted is only a single item self-assessed scale.

Wargocki *et al* (2000) attempted to evaluate the effects of outdoor air supply rate on perceived air quality, sick building syndrome (SBS) symptoms and productivity. The evaluations were conducted in a normally furnished office.

> *"Five groups of six female subjects were each exposed to three ventilations rates, one group and one ventilation rate at a time. Each exposure lasted 4.6 h and took place in the afternoon." (Wargocki et al, 2000, p222)*

The subjects were assessed, at intervals, for perceived air quality and SBS symptoms and evaluated whilst performing simulated office work. The results reported indicate that when ventilation was increased the subjects reported feeling generally better ($P<0.001$). Also, for all the simulated work tasks, such as addition, text typing, proof-reading and creative thinking, improvements were reported with increases in the ventilation, and in the case of text-typing the results reached significance ($P<0.03$). The inclusion of the creative thinking component into the assessment of simulated office tasks is an improvement in modelling the work processes of the modern office (Wargocki *et al,* 2000). Since creative thinking is one of the main assets of the modern office environment, and the results reported suggest that increased ventilation leads to the subjects reporting eased difficulty in thinking ($P < 0.001$). Therefore the ventilation requirements of the office occupiers become an important ingredient in creating a productive workplace. Whilst the rigour of the research conducted by Wargocki *at al* (2000) is acknowledged, it should also be acknowledged that the evaluation was undertaken in one office environment, therefore generalising the results would be questionable. Also the subjects used were female and therefore may include a gender bias.

Lighting

Abdou (1997) maintains that office occupiers believe that lighting is an important aspect of their office environment, with daylight being of particular importance. He suggests that significant improvement in office lighting can be a cost-effective way of increasing productivity.

Support for linking day lighting to human performance is presented by Heschong *et al* (2002). They present a re-evaluation of a previous piece of research to investigate the effects of day lighting on the grades of children in schools. The research conducted concluded that a statistical relationship existed between students access to daylight and student performance. Daylight was assessed using a scale 0-5, 0 = non-existent to 5 = highest quality of daylight. To establish the performance metric, only students that were exposed to highly standardised tests were used, including students from second to fifth grade in elementary schools. Whilst this research relates to improvement in grades of children, it is similar to the evaluation of office productivity, as the aim of both is to enhance human performance.

> *"If day lighting enhances the performance of children in schools, it is not too large a stretch to suppose that it might also enhance the performance of adults in office buildings or other workplace settings." (Heschong & Wight, 2002, p 8.91)*

Veitch (2000) proposes that the lack of research, by psychologists, in lighting and performance was probably as a consequence of the Hawthorne experiments. She therefore suggests that the research that has been undertaken tends to evaluate the lighting in economic terms rather than from the human perspective. She goes on to propose that apart from the requirement for lighting for visibility and task performance, there is also a requirement for lighting to influence social behaviour, communication and mood. It is these later elements that the retail industry has learnt to manipulate in an attempt to influence buyer behaviour (Bitner, 1992).

2.3.2 Layout

The debate in the literature that attempts to link the layout of the office environment and the performance of the occupiers tends to centre around the issue of open-plan versus cellular offices (Haynes *et al*, 2000), and attempts to match the office environment to the work processes (Stallworth & Ward, 1996; Laing *et al*, 1998; Mawson, 2002).

Ilozor & Oluwoye (1999) aimed to establish the impact of open-plan measures on the effectiveness of the facilities management of the space. They collected data from 102 open-plan offices from commercial office buildings in the central business district of Sydney, Australia. The data were collected using a questionnaire design, and completed by the facilities manager responsible for the office environment. Ilozar & Oluwoye (1999) present a conceptual model that attempts to link the following variables:

i) Open-plan Measures

ii) Management Control, and

iii) Effectiveness of Facilities Space Management

In assessing staff productivity Ilozar & Oluwoye (1999, p239) used the following question, which was scaled either yes or no, in their assessment of the effectiveness of facilities space management:

> *"Practice of measuring staff productivity, ME13"*

Ilozar & Oluwoye (1999, p244) conclude their analysis by stating that:

> *"A greater perceived support on informal meetings by open-plan workspace is associated with increased measuring of staff productivity."*

Whilst this research appears to offer evidence for a more productive workplace, care needs to be taken in how far the results can be generalised. Firstly, the study was undertaken in the business district in Sydney, and therefore any generalisation would have to be confined to similar commercial offices. Secondly, the productivity question only assesses if the office adopts a staff productivity measure, not a productivity measure in itself. And finally, and probably the main limitation of the research, the respondents were facilities managers and not the actual occupants of the office environments.

Ilozor *et al* (2002) attempt to make the connection between the use of innovative work settings and improved organisational performance, i.e. through change. The research was based on 102 work settings, with several null hypotheses on innovative work settings and organisational performance being tested using the Kruskal-Wallis H test. In contrast to previous published research (Ilozar & Oluwoye,1999) this research included a measure of the level of productivity. Although they do not make clear how the level of productivity was actually measured.

One of the conclusions drawn by Ilozor *et al* (2002) was that:

> *"The more a work setting is perceived to be innovative in terms of fostering staff interaction, the greater the measuring of staff productivity and the level of productivity." (Ilozor et al, 2002)*

This conclusion illustrates the use of innovative environments as a means of enabling greater interaction between office occupiers. This result also starts to give an indication as to the ingredients required when considering a creative and productive workplace. Ilozor *et al* (2002) concludes that the physical properties of the office environments can be used to influence organisational performance. Whilst this analysis is more developed than previous research undertaken (Ilozar & Oluwoye, 1999) it does suffer from the same main critique, which is that the data appear to be collected from facilities managers and not from the office occupiers themselves.

Previously, authors such as Stallworth & Kleiner (1996) have talked about *"Person-environment fit"* (p36), and Mawson (2002) claimed that productivity losses could be attributed to a mismatch between the office environment and the work undertaken in that environment.

> *"Contrast this with the approach taken to designing a manufacturing plant where detailed consideration would be given to the processes to be performed within the building, before then designing back from these to get the best fit." (Mawson, 2002, p1)*

Research undertaken by DEGW and BRE attempted to address the issue of matching the work processes and the office environment (Laing *et al*, 1998). The research question adopted was:

> *"Most office buildings and their environmental systems were designed for typical 9 to 5 activities, but how will they perform when that pattern of use changes?" (Laing et al, 1998, p1)*

The research undertaken attempted to address the issue of organizational work patterns and the working environment.

Three components (affinities) were investigated in greater detail:

i) Work Patterns

ii) Building Types

iii) HVAC Systems

The results included an assessment of the three components (affinities), to identify the optimum correlation of the working environment for the work patterns.

To help in understanding the various work patterns four new metaphors were developed by Laing *et al* (1998, p21-p24). They were:

> ***Hive**: "The hive office organization is characterized by individual routine process work with low levels of interaction and individual autonomy. The office worker sits at simple workstations for continuous periods of time on a regular 9 to 5 schedule (variants of this type include 24-hour shift working."*
>
> ***Cell:** "The cell office organization is for individual concentrated work with little interaction. Highly autonomous individuals occupy the office in an intermittent irregular pattern with extended working days, working elsewhere some of the time (possibly at home, at clients, or on the road)."*
>
> ***Den:** "The den office organization is associated with group process work, interactive but not necessarily highly autonomous. The space is designed for group working with a range of several simple settings, typically arranged in the open-plan or group room."*

> ***Club:*** *"The club office organization is for knowledge work: both highly autonomous and highly interactive. The pattern of occupancy is intermittent and over an extended working day. A variety of shared task based settings serve both concentrated individual and group interactive work."*

Having established the four work patterns, Laing *et al* (1998) use the work patterns to suggest four correspondingly different physical environments, with the inference that an optimal match between process and environment can be made. Laing *et al* (1998) offer a simple model to represent office-based work. The model is based on the amount of face-to-face interaction in the office, and the amount of flexibility the occupier has to work when, where and how they wish, i.e. autonomy. The limitations of this work, as acknowledged by the authors, is that the results are based on a small-scale study i.e. eight case studies[13]. Also whilst the research addresses the issue of the working environment and the work processes, it does not directly address the working environment and work performance, i.e. productivity.

Brennan *et al* (2002) presented findings from a longitudal study that aimed to evaluate the transition of office occupiers from traditional cellular offices to an open-plan environment. The measurement intervals adopted were before the move, four weeks after the move and six months after the move. Although 80 questionnaires were distributed at the interval points, only 21 participants responded to all three intervals. Acknowledging the small sample size as one of the limitations of the study, the results presented do have the benefit of being time series. The study included measures of satisfaction with the physical environment, physical stress, relations with team members and perceived performance. The performance measure adopted was a self-assessed measure, but had the benefit of being assessed on a 20-item scale.

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[13] The study presented in this thesis will adopt comparable work pattern classifications and consist of two sizable data sets.

> *"Perceived performance was assessed through a 20-item subscale consisting of items such as 'I am able to stay focused and 'on task' at work' and "I am able to complete my planned tasks for the day." (Brennan, Chugh & Kline, 2002, p289)*

The main conclusion drawn from the study was that the office occupiers were dissatisfied with their move to a new open-plan environment, and that dissatisfaction did not improve after the six-month adjustment period. Brennan *et al* (2002) concluded that the respondents found the openness of the environment counter productive in terms of increased disturbance and distractions. One of the limitations of the study is that the respondents were not sub divided into different work process, therefore comparisons between work processes could not be made. One of the main limitations of the study, acknowledged by the authors, was the lack of a control group. The inclusion of a control group would have allowed comparisons between the test group and the control group to be made. Therefore the comparisons would have established if the dissatisfaction was as a cause of the open-plan environment, or as a result of an intervening variable such as organisational issues.

The office environment can be used to establish brand identify, as well as a tool to attract and retain quality staff (Becker, 2002). Becker (2002) argues that the layout and use of the office can also provide workplace flexibility, thereby allowing firms to change and adapt without being restricted by office space. He goes on to argue that open-plan environments are a less expensive solution over time, as they require minimum alteration since occupiers can adopt a 'hotelling' policy. The idea of 'zero-time' space solution is introduced with the principles being that the space does not change over time, but the space policy does, i.e. employee desk ratio. Whilst Becker (2002) advocates non-territorial offices, no viable office protocols are presented (Laframboise *et al*, 2003). It should also be acknowledged that whilst Becker's (2002) idea of a non-territorial office, with every one adopting a hotelling policy, may sound attractive in providing the organisation with workplace flexibility, none of the firms studied actually adopted hotelling practices (Becker, 2002).

The notion that the workplace should not hinder an organisation's ability to respond to the changing business world is developed by Bradley & Hood (2003). They develop the idea of workspace flexibility (Becker, 2002) by proposing a minimalist approach to office design. Their main proposal is the need to keep the office free of clutter, which can restrict the organisation's ability to adapt and respond quickly to market forces. Bradley & Hood (2003) propose that to ensure the workplace improves corporate agility four golden rules should be adopted:

i) Systematically and frequently purge 'stuff' to enable mobility

ii) Design for 'busyness' in order to keep a 'buzz'.

iii) Reduce bespoke fixed fit-out components and adopt re-locatable components

iv) Systematically evaluate the utilisation of space and technology along side shifting work practices.

Whilst it may appear that the four golden rules represent good house keeping, the final golden rule supports the notion that the office environment should be designed, and adapted, to support the work processes, the aim being to minimise the mismatch between the office environment and the work processes (Mawson, 2002).

The trend towards open-plan environments has largely been driven by organisations aiming to reduce accommodation costs (Veitch *et al,* 2002). Veitch *et al* (2002) argue that facilities managers have responded to such pressure by creating open-plan environments with reduced space allocations. They suggest that by adopting the cost reduction paradigm, organisations run the risk of creating office environments that are ultimately uncomfortable and unworkable. Veitch *et al* (2002) maintain that the effects on the individual could be either direct, caused by adverse physical conditions, or indirect through psychological process such as lack of privacy or stress.

To establish the effects of the open-plan environment on occupier satisfaction Veitch *et al* (2002) collected data from 419 respondents located across three government offices. Both physical measurements were made, such as temperature, lighting, noise, ventilation and workstation details, as well as occupiers completing a 27-item questionnaire. The questionnaire consisted of 18 questions relating to satisfaction with the environment, 2 questions relating to overall satisfaction with the environment and two questions relating to job satisfaction.

Table 2:6 Satisfaction with environment: A three - factor model (Adapted from Veitch *et al*, 2002)

Satisfaction	Items
Satisfaction with Privacy:	visual privacy, conversational privacy, amount of noise from others' conversations, amount of background noise; amount of distraction, workstation size, degree of enclosure, ability to alter conditions; distance between coworkers; and aesthetic appearance.
Satisfaction with Lighting:	lighting quality, quantity of light on the desk, quantity of light for computer work, computer glare, and access to a view.
Satisfaction with Ventilation:	air quality, temperature, and air movement.

Using factor analysis Veitch *et al* (2002) created a three-factor model to represent the satisfaction with the open-plan office environments. Whilst the lighting and ventilation factors clearly represent satisfaction with the physical environment, the inclusion of the privacy component broadens the debate to include the behavioural environment (Veitch *et al,* 2002).

Whilst the espoused organisational benefits of open-plan environments relate to improved teamwork and communication (van der Voordt, 2004) the actual effects experienced by the occupier can be that of increased crowding and loss of privacy.

> *" Open-plan and shared offices have most complaints about lack of privacy – people have difficulty concentrating, dealing with personal matters and colleagues' annoying habits." (Nathan & Doyle, 2002, p26)*

Nathan and Doyle (2002) acknowledge that reducing the space allocation of individuals in the office environment can have both a positive and negative effect on office occupier's ability to do their jobs. The effect on the office occupier will be dependent on the complexity of the task involved.

> *"High density environments- or environments that people feel are crowded – seem to make complex tasks harder to do. But simple tasks become easier to do." (Nathan & Doyle, 2002, p26)*

The effects of open-plan environments are acknowledged by van der Voordt (2004), who proposes that office occupiers in an open-plan environment experience an increase in stimuli, both visual and acoustic, than occupiers working in enclosed cellular offices. He further proposes that office occupiers can respond in different ways to the increase in stimuli, with some perceiving the increase in stimuli in a positive ways, whilst others perceive the increase in stimuli as a mental burden that raises their stress levels (van der Voordt, 2004).

Whilst the aim of a high performance workplace would be to match the requirements of the individuals, and their work process, to the physical environment, the consequences of creating an office environment which is a mismatch could have an effect on both the health of the individual and their performance levels.

> *"Badly-designed or managed workplaces damage staff physical and mental well being" (Nathan & Doyle, 2002, p2)*

van der Voordt (2004) evaluated two Dutch case studies that had attempted to measure the effects of innovative workplace design on productivity. Whilst van der Voordt (2004) identifies the potential weakness of using perceptional measures of productivity, and calls for a number of indicators to be used, the case studies used adopt a perceived productivity measure. One of the case study reports an increase in perceived productivity the other reports a decrease in productivity. van der Voordt (2004) concludes that the differing responses can partly be explained by different initial situations. Although it is not explicitly stated, it appears that the inference is that the case study reporting a positive result was initially in an open-plan environment, whereas the negative case study was probably in cellular offices. This clearly illustrates the need to integrate a change management process into the relocation project (Laframboise *et al*, 2003).

From the results of the case studies, and a workshop exercise with experts, van der Voordt (2004) presents a summary of the positive and negative effects on work processes of innovative workplaces.

Table 2:7 Productivity effects on work processes (van der Voordt, 2004)

Positive	Negative
Free choice of appropriate workplace	More time spent on organising work
Culture change: work more consciously	Loss of time used for installation (logging on, adjusting furniture, tidying up)
Stimulus to work in a more organised way	Acclimatising time and again (different workplace; varying colleagues next to you)
No space for saving things, so you have to finish them	More time required to look up and store information

van der Voordt (2004) attempts to address two major issues which are specifically related to office layout. Firstly, it is proposed that there is an increase in shared areas, and a reduction in fixed dedicated workplaces. This approach replicates the ideas of a non-territorial office as presented by Becker (1990 and 1995). The second issue addressed relates to the debate between open-plan versus cellular offices, where van der Voordt (2004) acknowledges the advantages and disadvantages of each environment. He concludes that it is important to create an environment that allows occupiers to transfer information, whilst also accepting that there is a requirement for concentrated work. To resolve the potential tensions between the work process demand and the office environment provision van der Voordt (2004) proposes the use of a combi-office.

> *"One of the main reasons for using combi offices, with a mix of shared and activity-related workplaces, has been to overcome the disadvantages of office units (too closed, poor conditions for social interaction) and open-plan offices (too open, too many distractions)." (van der Voordt, 2004, p145)*

2.3.3 Summary

This section has demonstrated that the literature that claims to link the physical office environment to the productivity of its occupants can be subdivided into the comfort literature and the office layout literature. The comfort literature addresses the physiological elements in the office environment, and is based on the premise that if an office occupier is not physically comfortable then their productivity will be affected. The office layout literature can be further subdivided into literature that addresses the open-plan versus cellular office debate, and literature that matches the office layout to the work patterns of its occupants. Whilst the open-plan versus cellular office debate can tend to reinforce the prevailing paradigm of cost reduction, the issues of matching the office layout to different work patterns develops the human contribution debate. This changing emphasis allows consideration to be given to understanding how office occupiers actually use space. This view of office environments from the occupier perspective opens up an appreciation of the behavioural environment. It is starting to emerge that any theoretical framework for office productivity will consist of both the physical environment and behavioural environment, and in addition accommodate the different work patterns that office occupiers can adopt. The research that claims to link the behavioural environment with the productivity of its occupants will be reviewed in the next section.

2.4 Behavioural Environment

This section will aim to introduce, and develop, the concept of a behavioural environment. It will demonstrate that the behavioural environment is an integrated dimension of office productivity. Fundamentally, this section aims to explore how the office environment can affect the office occupier's behaviour and the social environment created by office colleagues.

The challenge to consider the workplace environment as more than just a physical environment can be traced back to the Hawthorne studies (Roethlisberger & Dickson, 1939). However it has been authors such as Steele (1986) and Becker (1981; 1990; 1995) who have attempted to broaden the debate from just the physical environment to include linkages between space, work patterns and organisational culture.

> *"This way of thinking about the connections between space planning and design and organizational effectiveness has been called the study of organizational ecology (Becker 1981; Steele 1986)." (Becker, 1990, p228)*

Bitner (1992) aims to establish, through a conceptual framework termed servicescape, the impact of the physical environment on the behaviour of both the customer and employees of service organisations. She proposes that service organisations are overlooking a valuable resource, that of the physical setting of the organisation.

> *"Services generally are purchased and consumed simultaneously, and typically require direct human contact, customers and employees interact with each other within the organizations physical facility." (Bitner, 1992, p58)*

Bitner (1992) suggests that the physical environment plays such a key role in influencing buyer behaviour for service organisations, that it should be integrated into the organisation's marketing solution. She discusses the issue of social interactions and concludes that the physical container, the environment, affects the quality, and duration, of interactions. Whilst Bitner (1992) believes that the physical setting can affect the behaviour of its occupants, she also acknowledges that creating an environment for a range of different behaviours is a complex issue.

> *"One of the challenges in designing environments to enhance individual approach behaviours and encourage the appropriate social interactions is that optimal design for one person or group may not be the optimal design for other." (Bitner, 1992, p 61)*

Bitner (1992) concludes by presenting the servicescape framework that identifies the three environmental dimensions:

i) Ambient Conditions,

ii) Space and Function; and

iii) Signs, Symbols and Artefacts.

The Ambient Conditions and the Space and Function dimensions replicate dimensions previously discussed in the physical environment, i.e. comfort and layout respectively. The Signs, Symbols and Artefacts dimension acknowledges the individual within the environment, and includes such things as personal artefacts and style of décor. An important behavioural pattern acknowledged in the servicescape framework is that of the social interaction between, and among, customers and employees (Bitner, 1992).

Brenner & Cornell (1994) aimed to investigate the possible behavioural tensions within office environments by the evaluation of office environments that had been specifically designed to enhance privacy and collaboration. The environments evaluated consisted of a small enclosed area called a personal harbour workspace, and a group area called common space. The personal harbour gave its occupant the opportunity to withdraw physically and obtain territorial privacy. The commons area consisted of group space, which was configured according to work process, and technology needs (Brenner & Cornell, 1994). The environments created conformed to the "commons" and "caves" metaphor (Hurst, 1995; Steele, 1981) . The meaning of the metaphor is that when people are in the "common" areas they are available to interact with other group members, and when they wish to be on their own they can withdraw to the caves, thereby signalling they want their privacy.

Brenner & Cornell (1994) investigated the willingness of the team members to trade off the need for privacy with the need for collaboration with other team members. They reported that the need for privacy diminished over the time of the experiment, and concluded that this was as a consequence of the team becoming more cohesive. Also whilst the door on the personal harbours was not used as often as expected, it was deemed to be important by the office occupiers, as it provided them with an element of control over their environment, an issue previously identified by Leaman & Bordass (2000). The door was used to restrict their level of interaction with the other team members.

> *"Privacy can be defined as the degree to which one's social interactions are regulated."*
> *(Marquardt, et al, 2002, p8)*

Becker & Steele (1995) reiterated the benefits of their organisational ecology concept, by claiming that it can transform physical workplace environments to support the organisation's business processes. They propose that to ensure that the work environment supports the organisation's objectives, then consideration needs to be given to the work processes undertaken, and the culture the organisation wants to portray with its physical workspace. Becker & Steele (1995) suggest that for organisations to achieve organizational ecology, consideration needs to be given to the following three components.

> *i) Decisions about the physical setting in which work is carried out.*
>
> *ii) Decisions about the processes used for planning and designing the workplace system*
>
> *iii) Decisions about how space, equipment, and furnishings are allocated and used overtime.*
>
> *(Becker & Steele, 1995, p12)*

Emphasis is placed on the role the physical environment can play in representing organisational culture. The ultimate proposal, presented by Becker & Steele (1995), is that the physical environment can be used strategically, to demonstrate a change in organisational culture.

> *"The planning and design of the workplace can, however, be used – or serve – as a deliberate catalyst for organizational change including the culture of the organization."(Becker & Steele, 1995, p58)*

Ultimately, Becker & Steele (1995) present an argument for using space to change organisational culture, which ultimately means that the physical environment will influence, and change, the patterns of behaviour in the physical environment.

Stallworth & Ward (1996) reiterate the point that office evaluations have traditionally been preoccupied with the physical environment, at the expense of understanding the social environment. They acknowledge that research that attempts to link productivity, work setting and behaviour is a complex issue and is in its infancy, and argue that with more and more people working in office accommodation there is clearly a business need to address the issue.

Whilst authors such as Becker (1990) and Becker & Steele (1995) argue for a non-territorial office with restricted allocation of dedicated desks, other authors aim to establish the effects of such a strategy on the office occupants (Wells, 2000). The adoption of flexible work patterns, such as hotelling effectively means that employees work in a range of temporary workplaces with no particular area they can call their own. This view could overlook a behavioural need of some individuals, such as the need to express their identity and personality through the modification of their workplace environment.

To establish whether office personalisation was associated to employee well being, Wells (2000) undertook a survey of 20 companies in California. A survey of 338 office workers was conducted, with 23 of the participants being interviewed and observed in their work setting.

Wells (2000) proposed that personalisation of the work environment is a form of territorial behaviour, effectively a behaviour pattern that would be suppressed in a non-territorial office (Becker & Steele, 1995). Marquardt *et al* (2002) defines personalisation as follows:

> *"Personalisation is the process whereby workers publicly display personally meaningful items." (Marquardt et al, 2002, p12)*

The argument is developed by Wells (2000), to suggest that office occupiers can use their personal belongings to mark their territories, and they can even be used to regulate their social interactions with other colleagues. Marquardt *et al* (2002) argues that organisations can use the workspace to establish an individual's organisational identity.

> *"The workspace provided by the employer might also confirm one's identity and communicate one's position within the organisation." (Marquardt et al, 2002, p12)*

Clearly a potential tension could exist between the organisational requirements, perceiving personalisation as office clutter, and the individual who perceives personalisation as a way of establishing their identify in the workplace.

Wells (2000) concluded that organisations that adopt a more lenient personalisation policy report higher levels of organisational well-being. The implication for organisations is that people, women more than men, want to be able to personalise their workspace.

> *"Therefore, restricting employee personalisation may be associated with reduced satisfaction with the physical work environment, reduced job satisfaction, and reduced employee well being." (Wells, 2000, p251)*

To ensure office environments work, from both an organisational and individual perspective, consideration needs to be given to the types of behaviour the office needs to enable. Increasingly, offices are becoming environments that need to create and transfer knowledge to other team members. It is this acknowledgement that has led Ward & Holtham (2000) to conclude that physical space is the most neglected resource in contemporary knowledge management. Price (2001) acknowledges the weakness of previous office environment research, and calls for a new research paradigm, one that acknowledges space as a resource that can be used as a conduit for knowledge management. He calls for further research and proposes two possible test instruments, a workplace connectivity indicator, and a workplace culture indicator. The proposal being that the cultural environment acts as an enabler for knowledge management, and the physical environment acting as a conduit for connectivity between its occupiers (Price, 2001).

If office environments are to act as conduits for knowledge creation and transfer, then the debate widens to include the notion that work environments can be created to support creativity (Stokols, Clitheroe & Zmuidzinaz, 2002). Stokols *et al* (2002) propose a theoretical framework for evaluation which aims to evaluate the effects of both the physical environment, termed environmental distractions, and the social environment, termed social climate, on the perceived creativity of occupants in the workplace. The 97 participants used in the study consisted of staff from administrative units within the University of California (UCI), (74%) and one off-campus organisation, (26%). The occupier's perceptions of support of creativity, job satisfaction, personal stress and their ratings of the physical and social environment were all obtained through the use of a questionnaire. Additionally, objective measurements were obtained pertaining to the physical environment.

Having analysed the results of the research Stokols *et al* (2002) concluded that:

> *"A more positive social climate was associated with greater perceived support for creativity at work, and high levels of environmental distraction were associated with less perceived support for creativity as work." (Stokols et al, 2002, p144)*

One of the limitations of the study was that it was based on a cross-sectional rather than longitudal data, therefore, as the authors acknowledge, the direction of association cannot be established. It cannot be determined if the positive social climate causes support for creativity, or whether it is the greater perceived support for creativity that causes a more positive social climate (Stokols *et al,* 2002). With regards to environmental distraction, Stokols *et al* (2002) conclude that it is more probable that high levels of distraction, leads to lower levels of perceived support for creativity. The implications of the research are that creative environments could possibly be created if attention is given to both the physical and the social environment, ideally by creating an enabling social climate whilst ensuring that distractions caused by the physical environment are minimised.

Acknowledging the small sample size, and the fact that the sample is largely drawn from University staff, the research presented does offer some evidence to support the notion that the workplace consists of both physical and social dimensions. In addition, both of these dimensions can have an impact on office occupier behaviour, in this instance creativity (Stokols *et al,* 2002).

Research undertaken by Nathan & Doyle (2002) aimed to establish the views of occupiers who worked in office environments. The research evaluates offices from two standpoints. Firstly, the way that office environments can communicate organisational culture. Secondly, the territorial nature in which occupiers view their space, i.e. how they attach meaning to their work area.

Nathan & Doyle (2002) reiterate the tensions that can exist between individual requirements for privacy and territory, and organisational requirements for open-plan collaborative workspace. Although Nathan & Doyle (2002) acknowledge that individuals, some more than others, require privacy and territory, there is also a requirement for company. The challenge facing organisations is to create offices, and cultures, that enable both activities to coexist.

> *"Rather than neglecting the relationship between buildings, organization and behaviour, or attempting to use buildings to exploit behaviour patterns, it is the sanest to try to design buildings which permit all possible behaviours to coexist without coming to conflict." (Duffy, 1992)*

Nathan & Doyle (2002) add support to Duffy's (1992) proposal, by acknowledging the behavioural and social dynamics within the workplace. In an attempt to categorise the workplace behaviours they presents six main behaviour types.

Table 2:8 Behaviour types and typical comments (Nathan & Doyle, 2002)

Behaviour Type	Typical Comments
Colonising	'My in-trays are always full ... I have different degrees of 'in' ... really urgent work I just put in a pile right in front of me. Stuff that doesn't fit into the in-tray goes on the shelf next to me. I try to operate a hierarchy of surface areas.'
Warmdesking	I have a favourite hotdesk. The best spots allow you to face the door, see who's coming in. People descend on you when you're working - you need to be prepared.
Communing	The hotdesking area at work is as much a gathering spot, a place to chat as a place to work. When coming to the office, my priority is to come in, meet and interact with people I work with rather than doing work as such
Keeping a low profile	Privacy is a very serious issue in this space. The management has not provided any viable private space for confidential talks, disciplining and so on. Staff use the canteen, reception area or training rooms for the most part. However, because everyone works on the same level, it's obvious when someone needs to talk.
Converting and customising	My screen is also my workplace ...everything I need is always there.
Living	This is where I spend up to 12 hours a day. It's set up to function exactly as I want it. Books, music coffee, laptop, sofa, bin. When I'm working well, it's my favourite place.

Nathan & Doyle (2002) acknowledge the contrasting needs of individuals and conclude that office occupiers need space sovereignty, i.e. some ongoing control over their environment and its management. The balance between the individual, the team and the organisation needs to be sought. An insufficient change in organisational culture can be a more significant reason, than office design, as to why new office environments do not work, a view previously expressed by Turner and Myerson (1998).

In an attempt to create design criteria to allow the coexistence of both individual and team work, Olson (2002) created, and evaluated, a database of individual projects from multiple US-based clients between 1994 and 2000. The database contained 13,000 responses, which had been gathered by questionnaire. Olson (2002) attempts to establish the workplace qualities that have most effect on the occupier's individual performance, team performance and job satisfaction. One of the limitations of the study is that it does not separate individual performance, team performance and job satisfaction, but creates an aggregate score. Acknowledging this weakness, Olson (2002) identifies that the workplace quality that has the strongest effect on its occupants is the ability to do distraction-free solo work. The second workplace quality to affect occupiers is support for impromptu interactions. Clearly, the tension in office environments between privacy and collaboration is brought to the surface.

Another limitation of the analysis was that data for work processes was not collected, although data were collected that could be categorised by four functional job types, i.e. managers, professionals, engineers and administrative.

Olson (2002) presented results for the amount of time the four functional job types spent doing focused, quiet work, Managers (48%), Professionals (62%), Engineers (64%) and administrative (61%). Olson (2002) argues that when people wish to undertake distraction free work, the major cause of distraction is other people's conversations. Also, occupiers that are in open-plan, or shared offices, are more frequently distracted by other people's conversations than people who work in private offices. He suggests that on average office occupants spend 25% of their time making noise, such as having conversations, near other people's individual workspaces. Therefore with an open-plan environment, that has a high density of workers, one individual can simultaneously affect eight other office workers.

Whilst acknowledging the disadvantages of people having conversations in the workplace, Olson (2002) also establishes the advantages of impromptu interactions.

> *"While occupying less time than quiet work, this second most time-consuming interactive mode is critical to business success. Verbal interactions are needed to transact business effectively."(Olson, 2002, p41)*

Olson (2002) presents results that show that the majority of respondents (87%) believe that they learn through informal interaction, such as casual conversations, impromptu problem-solving sessions, as opposed to learning through formal interactions; training and scheduled meetings. This result demonstrates that office occupiers value informal interactions and informal learning more than formal learning. However, he suggests that the scores for informal learning from both private offices and open-plan offices are very similar, and therefore concludes that the idea that people in open-plan environments can learn more by overhearing other peoples conversations may need to be questioned.

In contrast to Olson's (2002) findings, Sims (2000) presented findings from a case study evaluation that deliberately designed space around teams, with the intention of increasing team communication and shared learning. It was called 'creative eavesdropping', and it was claimed that by adopting such a team centred approach, cycle times were reduced by 25%. In addition the space required for the teams reduced by 43% (Sims, 2000). Although a limitation of this research is that whilst headline figures are presented, the research data are not provided.

Olson (2002) concluded that:

> *"Quiet, individual work and frequent, informal interactions are the two most time-consuming workplace activities and are the two with the greatest effects on performance and satisfaction." (Olson, 2002, p46)*

Finally, Olson (2002) proposes that the answer to the potential tension between interaction and distraction is to create office environments that offer a high degree of enclosure, i.e. private offices. Whilst this proposal may address one side of the equation, the issue of the distraction free work, Olson (2002) does not appear to offer a solution for the other side of the equation, that is to say environments that allow informal interaction to occur.

The issue of distraction in the workplace is specifically addressed by Mawson (2002). He argues that anything that takes attention away from the task in hand, is effectively a distraction, and therefore impacts on the performance of the individual. Mawson (2002) develops the argument by suggesting that when individuals are focused on an individual task they are in a flow state, and when they are distracted they are brought out of that flow state. The concept of workflow can be traced to DeMarco & Leister (1987). They proposed that there is a time requirement for an individual to reach a deep level of concentration, termed ramp-up time. If distracted then the individual's flow of concentration would be broken, therefore requiring further ramp-up time to reach the same level of concentration previously attained. Mawson (2002) argues that over the period of a day, the cumulative effect of all the distractions leads to a disruptive, and less productive day. Cornell (2004) also supports the concept of workflow, and defines the flow state as:

> *"The optimal experience of flow is achieved when nearly all resources are concentrated on one task." (Cornell, 2004).*

Cornell (2004) proposes that to achieve optimal flow state, distractions need to be kept to a minimum. The concept of workflow, as presented by Mawson (2002) and Cornell (2004), appears to suggest that productive work is only achieved when individuals work alone. The main conclusion drawn is that the office environment needs to be a distraction free work environment. This stance does not acknowledge different personality types, and assumes one work process, i.e. individual. The major limitation of this conclusion is that it does not acknowledge the benefits that can be obtained from different work processes, i.e. team and collaborative work.

An extensive literature review of research that attempts to establish links between the ways that knowledge workers collaborate and the physical environment provided, was undertaken by Heerwagen *et al* (2004). The basis of the review was the research question:

> *"How can the physical design of the workplace enhance collaborations without compromising an individual's productivity?" (Heerwagen et al, 2004, p510)*

Heerwagen *et al* (2004) defines the nature of knowledge workers as being a combination of high cognitive skills and social interaction. They develop the argument to suggest that there are two basic needs of knowledge workers. They are:

I. Time to work alone to think, analyse and reflect.

II. Time to interact with others so that ideas can be generated and evaluated.

In common with Mawson (2002) and Cornell (2004), Heerwagen *et al* (2004) acknowledges the benefits of private individual work, although in contrast to Mawson (2002) and Cornell (2004), Heerwagen *et al* (2004) acknowledges the benefits, and the need for collaborative work of knowledge workers.

It is proposed that collaborative knowledge work consists of two dimensions, which are the social dimension and the individual dimension (Heerwagen *et al,* 2004). They also propose that the social dimension can be subdivided into three components, with each component being dependent on the amount of time spent with colleagues. The three components are:

I. Awareness

II. Brief Interaction

III. Collaboration

The awareness component relates to the eavesdropping concept presented by Sims (2000), the idea that office occupiers have a general awareness of what is going on in the office environment just by overhearing office conversations. Heerwagen *et al* (2004) proposes that the key physical requirements to ensure that the awareness dimension is supported are visual and aural accessibility. The physical requirement proposed is that of a highly open environment. Heerwagen *et al* (2004) acknowledge the potential problems of a high-awareness environment as being loss of privacy, loss of confidentiality, distraction and interruptions, although they argue that in an open environment interruptions and distractions may be reduced because of non-verbal and behavioural cues.

> *"When people are focused on an individual task, their posture, eye gaze and demeanour indicate they are not available for conversation. However, if they look up, make eye contact or walk around, others are more likely to perceive them as available for interaction." (Heerwagen et al, 2004, p514)*

Whilst some people may observe the behavioural cues for interaction others may not, therefore to ensure interruptions and distractions are kept to a minimum office protocols would need to be introduced (Brennan *et al*, 2002; Sims, 2000).

Heerwagen *et al* (2004) identifies the benefits to the knowledge worker of ad hoc brief interactions with colleagues. According to Heerwagen *et al* (2004) brief interactions can be both intentional and unintentional, and can occur in many locations, i.e. at people's desks, in the corridor and near central services. The location of the brief interaction can be considered an 'information exchange' (Heerwagen *et al,* 2004). They present the argument that the important predictors of interaction are layout and circulation. The "line of sight", i.e. visibility, within an office environment can influence the amount of interaction within the office (Heerwagen *et al,* 2004).

Commenting on the research that attempts to link collaborative behaviours and physical space Heerwagen *et al* (2004) conclude:

> *"Given the high interest in the topic of collaboration, there is a surprising dearth of research on the link between collaborative work processes and space." (Heerwagen* et al, *2004, p520)*

Becker & Sims (2001) identify that patterns of interaction between colleagues are greater for open environments than closed office environments. They argue the benefits of open-plan environments for communicating, and in the building of relationships with colleagues, such as social behaviour.

Reviewing the literature that aims to establish links between individual work and physical space, Heerwagen *et al* (2004) establish the benefits of individual workspaces that support focused concentration by reducing distractions and interruptions. They acknowledge that providing this type of environment is in tension with the desire to create an environment that enables interaction. In evaluating the tension between collaborative and individual work Heerwagen *et al* (2004) warn that have if too much emphasis is placed on interaction as the dominants behaviour pattern, then it may affect the individual's ability to work effectively.

Becker & Sims (2001) propose that when occupiers need to concentrate they should move to quite spaces elsewhere in the office. This assumes that the office worker has the flexibility to leave their desk and the autonomy to work flexibly (Laing *et al*, 1998).

Finally, Heerwagen *et al* (2004) conclude that creating collaborative office environments requires the integration of both the social and the individual factors, however little research exists that links collaborative behaviour to the physical space.

A piece of research that attempts to evaluate the impact of the workplace environment on the individual's privacy and team interaction is presented by Peterson & Beard (2004). They acknowledge that little independent research has been undertaken on new workplace designs, and work environment manufacturers had largely funded research that had been undertaken. Therefore Peterson & Beard (2004) evaluated a new work environment, which had been designed to include commons and personal harbours, in response to the need for both interaction and privacy. The design was based on the "caves and commons" metaphor (Hurst, 1995).

Data were collected from a large petroleum company that had formed a cross-functional team to design, develop, and implement an enterprise-wide information system (Peterson & Beard, 2004). A new work environment was created for the team with the objective of providing improved collaborative workspace, as well as providing private workspace. The team members were surveyed by questionnaire after working in the work environment for one year. The cross-functional team consisted of 15 members, and all returned their questionnaire. It could be argued that from a research design point of view, a longitudal survey would have been more beneficial than a cross sectional survey, especially if conclusions about increased performance are to be established. Also the sample size is relatively small, and only represents one company, therefore the possibility of statistical generalisation is restricted.

Peterson & Beard (2004) report that with regards to the individual workspace, i.e. the personal harbours, the participants reported that they were satisfied with the visual privacy that it provided, and the ability to concentrate, and the amount and quality of work they could accomplish. However, participants did report that they were not satisfied with the auditory privacy of the individual workspace. Peterson &

Beard (2004) acknowledge that the results appear contradictory, participants report that they are not satisfied with the auditory privacy, such as noise levels, yet they report to be satisfied with their ability to perform their work. Peterson & Beard (2004) explain that the doors on the personal harbours contain a white noise system, i.e. when the door is shut all background noise is eliminated. However observation of the office work methods revealed that people did not close the harbour door, therefore not activating the white noise system, and consequently allowing noise from the common areas into the individual workspace. The door was provided for the office occupiers as a means of regulating their interaction (Marquardt, 2002), however the occupiers were not exercising that option.

The respondents reported general satisfaction with the group area, i.e. commons (Peterson & Beard, 2004). Specifically the respondents reported that they were satisfied with the access and interaction with other group members. They also reported that they were satisfied with the quality, and amount of work the group accomplished. One issue that the respondents reported some dissatisfaction with was the lack of suitable area for the display of group information, an issue previously identified by Becker & Steele (1995).

> *"Displayed thinking, especially using the simple anonymous feedback medium of Post-It notes, allows people to challenge ideas and suggest new ones without fear of confrontation." (Becker & Steel, 1995, p82)*

Peterson & Beard (2004) finally concluded that using the working environment to enable team collaboration and communication also leads to team cohesiveness. The results indicate that 85% of the participants reported feeling a sense of closeness, and camaraderie, to other team members, indicating the behavioural component of the office environment (Peterson & Beard, 2004).

In an attempt to address the differing needs of occupiers Fleming (2004) proposes a conceptual framework. He proposes that assessment of work environments should include the occupier perspective. Subsequently, he develops an argument for behavioural assessment of work environments to complement the physical assessments.

> *"The mechanistic, quantitative nature of building performance paradigms fails to take into account the effect of occupiers' perceptions of their environments. Facility managers currently see buildings as containers of products and not containers of people. Products are measured against technical performance specifications rather than the idiosyncratic thoughts and perceptions of the building occupants." (Fleming, 2004, p35)*

Fleming (2004) argues that to understand the behavioural environment, consideration needs to be given to assessment methods from the psychological literature. He makes specific reference to the work of Murray (1938) as a way of describing the environments from either a detached observer stance (alpha press), or from the participants' stance (beta press). Fleming (2004) argues that Stern *et al* (1956) developed the understanding of the beta press by splitting it into two components, the "private beta press" and the "consensual beta press". Adoption of this approach could be an appropriate way of establishing the needs of the individual in an office environment (private beta press) and the needs of the team (consensual beta press).

This approach contributes to the debate by proposing a conceptual framework that establishes that traditional property performance has largely concentrated on the alpha press measures, such as observations by detached non-participants (Fleming, 2004). It develops the argument by proposing that a greater understanding of the behavioural environment can be obtained by the use of beta press measures; the occupier perspective.

Support for Fleming's (2004) call for a paradigm shift with regards to evaluation of office environments is found with Duffy (2000) and Haynes & Price (2004). Duffy (2000) proposes that office environments have changed relatively little over the last 20 years. Duffy (2000) attributes the lack of development to a preoccupation with hierarchical cultures, Taylorist mentalities and a cost reduction emphasis. Haynes & Price (2004) argue that traditional office research has tended to adopt a purely rationalist paradigm, with the missing component for a theoretical framework being the consideration of the behavioural environment. Haynes & Price (2004) propose that a possible way of understanding the behavioural environment would be to consider the connectivity that takes place in an office environment. They go on to suggest that office connectivity may be best understood by the use of a metaphor from the area of complex systems. The metaphor proposed is that of the complex adaptive system (Kauffman, 1995). The idea being that if knowledge creation, and knowledge transfer are outputs of a modern office, then offices need to have a critical density of interaction. People who sit at their desks working on individual processes in a passive way do not create an adaptive system. In contrast an office environment that has people interacting continually can be chaotic and disruptive. Therefore the proposal is that for optimum interaction to occur, without the disadvantages of distraction, offices need to work within a certain zone, that zone being the edge of chaos (Waldrop, 1992).

Haynes & Price (2004) argue that the issue of connectivity has previously occurred in the new workplace debate through the metaphor of "caves and commons" (Hurst, 1995; Steel, 1988).

Since office work can be considered as both individual and collaborative in nature, then office environments must aim to achieve maximum interaction whilst at the same time not affecting concentrated individual work (Haynes & Price, 2004).

> *"The complex adaptive workplace perspective would argue that caves and commons sustain a higher degree of connectivity." (Haynes & Price, 2004, p11)*

2.4.1 Summary

This section had drawn attention to the role that the behavioural environment plays in the productivity of office occupants. The stance adopted is very much that of the occupier perspective. The adoption of this stance reveals how office occupiers make sense of their work environment, and attempt to create a sense of belonging through personalisation of their work environment. The occupier perspective also establishes the potential tension between individual private work, and team based collaborative work. The review of the behavioural literature has established that this is an area that requires further research, and will therefore form the basis of this study.

2.5 Conclusion

This chapter has attempted to establish that there is no universally accepted definition of how office productivity should be measured, let alone an agreed methodology. Whilst inputs and outputs can be clearly defined in a manufacturing context, the same cannot be said of an office environment. There has been an increasing shift in emphasis in office work from process type work to more knowledge type work. It has therefore become more complex to measure office productivity outputs. Whilst there appears to be no universally accepted means of measuring office productivity, there does appear to be acceptance that a self-assessed measure of productivity is better then no measure.

The main body of literature that attempts to link office environments and productivity largely address the physical environment. The physical environment can be subdivided into comfort and layout. It could be argued that the comfort research establishes the basic human needs of the office environment. The literature relating to the office layout appears to revolve around two main debates; those of open-plan verses cellular offices, and the matching of the office environment to the work processes. It could be argued that the open-plan debate has led to cost reduction as the prevailing paradigm, with regards to office environments. Also to match environments to work processes requires a greater understanding of what people do in offices, which is still a subject of much debate.

The main gap in the literature is the lack of appreciation, and integration, of the behavioural environment. Office environments need to enable both collaborative work and individual private work to coexist without causing conflict between the two.

Since, there appears to be no universally accepted framework for the assessment of office productivity it is proposed that any theoretical framework for office productivity will consist of both the physical environment and behavioural environment, and in addition accommodate the different work patterns that office occupiers can adopt. A theoretical framework for office productivity will be further developed in the next chapter.

Chapter 3

Research methodology

3 Research methodology

3.1 Introduction

This chapter aims to present a justification, and rationalisation, as to the appropriateness of the research strategy adopted. The chapter has two main components, those of research philosophy and research design. The intention is to demonstrate that this research is built on firm philosophical foundations, and that the research design is congruent with the research philosophy. Once this is established, the detail of the research design will be presented, with specific attention given to the design of the measurement instrument.

It is important to place emphasis on the philosophical elements of research, as the lack of such considerations has been the subject of recent criticisms of workplace research (Cairns, 2003). It is therefore intended that all philosophical assumptions are made explicit, with specific attention given to ontology, epistemology, human interest and methodology (Burrell & Morgan, 1979). It will be demonstrated that the rational development from ontology, epistemology and ultimately human interest will lead to a congruent and appropriate methodology.

To demonstrate compliance with the research methodology the main components of research design will be made explicit. The research design will start by presenting a theoretical framework, which aims to place this research into context with the literature. It will be shown how the research hypotheses are derived from the theoretical framework, thereby clearly stating the testable propositions of the research. All the stages of designing the research instrument will be presented in an attempt to demonstrate the validity, reliability and generalizabilty of the research process. The administrative elements of data collection will be discussed, with comparisons being made between the different administrative processes used for the two data sets involved in this research. In the final part of this chapter, attention will be given to the structure of the data analysis.

It is intended to demonstrate an overview of the analysis techniques used in testing the research hypotheses. The structure of this chapter can be seen in Figure 2.1.

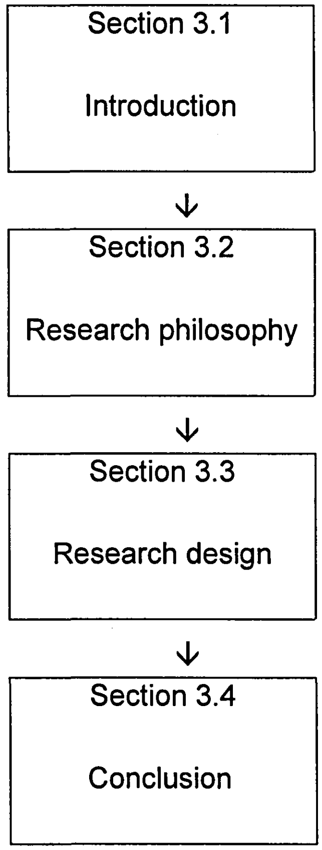

Figure 3.1 Structure of Chapter 3

3.2 Research philosophy

It is appropriate to start this section by considering the philosophical foundations on which research can be based. Since the research process is more than just the collecting of data and the interpretation of the results.

> *"By putting forward answers to research questions you are engaging in the process of debate about what can be known and how things are known. As such, you were engaging with philosophy." (Kitchin & Tate, 2000, p1)*

Easterby-Smith *et al.* (2002) present two philosophical traditions or paradigms, positivism and social constructionism, as alternative ways of undertaking social science research.

To establish the key differences between the two philosophical traditions of positivism and social constructionism, it is worth starting with a couple of definitions.

Positivism can be defined as:

> *"The key idea of positivism is that the social world exists externally, and that its properties should be measured through objective methods, rather than being inferred subjectively through sensation, reflection or intuition." (Easterby-Smith et al, 2002, p28)*

Social constructionism can be defined as

> *"The idea of social constructionism then, as developed by Burger and Luckman (1966), Watzlawick (1984) and Shotter (1993), focuses on the ways that people make sense of the world especially through sharing their experiences with others via the medium of language." (Easterby-Smith et al, 2002, p29)*

Comparing and contrasting the two definitions highlights the different role that the observer of the research undertakes. In the positivist paradigm the researcher must maintain independent from the subject of the research, so as not to introduce any bias. In contrast under the social constructionism paradigm the observer is an integral part of what is being observed.

It could be argued that positivism has been the prevailing research paradigm for social science with its strong connection and affinity with the natural sciences. However, since the early 1980s the competing paradigm of constructionism has developed momentum, with supporters proposing that it should be the prevailing paradigm for social science research (Easterby-Smith et al, 2002). This is a debate that is paralleled in the area of facilities management literature with calls for a range of research approaches (Grimshaw & Cairns, 2000; Cairns, 2003).

Having identified the two main philosophical traditions of positivism and social constructionism; it seems appropriate to explore further the philosophical differences between the two paradigms. The aim is to establish a supporting rationale that justifies the appropriateness of the philosophical stance on which this research is based. It is also intended that by adopting such an approach, the specific concerns of the facilities management research community can be addressed (Cairns, 2003). Cairns (2003) presents the argument that the emergent field of facilities management research lacks a theoretical foundation, and therefore proposes the need to consider the philosophical basis on which research is undertaken.

To ensure that the appropriate methodological choices are made, it is worth widening the philosophical debate to include terms such as ontology and epistemology. It is intended that the research assumptions adopted in this study are made explicit.

> *"All social scientists approach their subject via explicit or implicit assumptions about the nature of the social world and the way in which it may be investigated." (Burrell & Morgan, 1979, p1)*

To assist in the development of these ideas, it is useful to use a framework, proposed by Burrell & Morgan (1997), to debate the assumptions adopted in social science research (Figure 3.2).

The horizontal dimension, in Figure 3.2, represents a continuum with subjectivity at one end and objectivity at the other. The vertical dimension represents the corresponding assumptions for ontology, epistemology, human nature and methodology. Burrell & Morgan (1979) present the idea of the incommensurability thesis, the principle being that by accepting the assumptions of one of the paradigms you in effect deny some of the assumptions of the alternative paradigm.

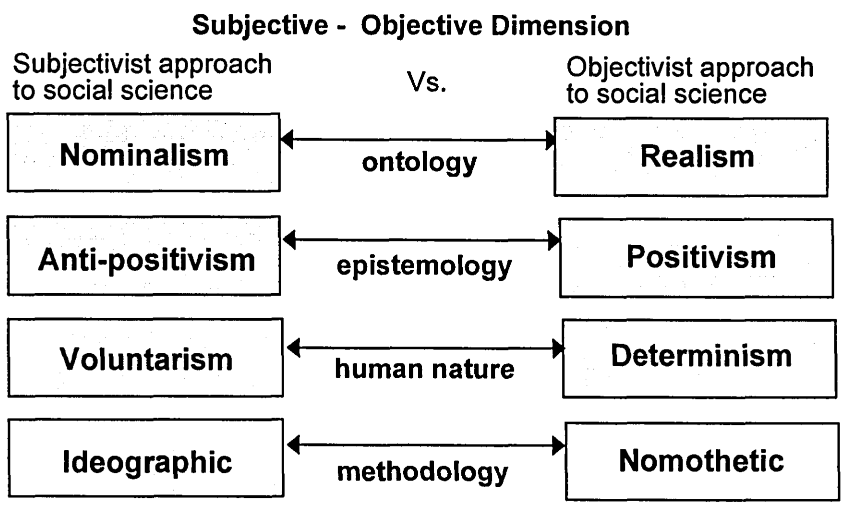

Figure 3.2 Assumptions about social science research (Adapted from Burrell & Morgan, 1979)

To ensure that all the assumptions of this research are made explicit, each of the assumptions about social science research will now be discussed individually.

3.2.1 Ontological assumption

To address the ontological assumption consideration needs to be given to the question. *What is the nature of reality?* (Creswell, 1994).

The realist view on reality, and existence of being, is that reality is constantly in existence and it is external to the researcher. In contrast norminalism takes the view that the researcher and reality are one and the same; reality is what people make of it. It is the individual's perceptions of a socially constructed world that make reality (Hussey and Hussey, 1997).

Whilst this section will compare and contrast the objective and subjective approaches in their extreme, it should be noted that there are a range of ontological assumptions that could be plotted on a continuum between positivism and constructionism (Figure 3.3).

Positivist ◄		Approach to social sciences			**Constructivist** ►
Reality as concrete structure	Reality as a concrete process	Reality as a contextual field of information	Reality as a realm of symbolic discourse	Reality as a social construction	Reality as a projection of human imagination

Figure 3.3 Continuum of core ontological assumptions (Adapted from Morgan and Smirich, 1980, p492)

Reality as a concrete structure means that the social world is the same as the physical world. This approach, termed the "objectivist", assumes that the same positivistic methods used for natural sciences can be used for the social sciences.

Objectivism can be defined as:

> *"Objectivism is an ontological position that asserts that social phenomenon and their meanings have an existence that is independent of social actors. It implies that social phenomena and the categories that we use in everyday discourse have an existence that is independent or separate from actors." (Bryman, 2001, p17)*

The other end of the continuum, termed the "subjective", identifies the reality of the social world as being a projection of human imagination. Whilst it is acknowledged that research into office environments and productivity can be undertaken from a range of different ontological standpoints (Cairns, 2003), this research adopts the ontological assumption that the concept of office productivity has a reality of its own. This reality is external to the office occupiers and therefore can be researched as if it were a tangible reality. Adopting such a research stance can be considered the traditional approach to undertaking managerial research (Bryman, 2001).

Bryman (2001) proposes that management research, into organisations and culture, has to a large extent adopted the objective reality stance. He suggests that objectivism has been the 'classic' way of conceptualising organisations and culture.

> *"Cultures and subcultures constrain us because we internalize their beliefs and values. In the case of both organisations and culture, the social entity in question comes across*

> *as something external to the actor and as having an almost tangible reality of its own. It has the characteristics of an object and hence of having an objective reality." (Bryman, 2001, p17)*

It should be acknowledged that the traditional approach to undertaking management research, and specifically workplace research is being questioned (Cairns, 2003). The limitations of adopting an objective reality are identified as the acceptance of a singular reality, rather than the multiple realities.

> *"The one definition of philosophy that I find problematic is that of dealing with "ultimate reality", as if such an understanding was achievable. It is with this definition that I now want to take issue, and in so doing, to take issue also with "traditional" approaches to dealing with business problems and with "traditional" forms of professional knowledge, and to lead into the grounding of a philosophy of workplace that embraces complexity and "multiple realities" (Beech and Cairns, 2001) rather than "ultimate reality"." (Cairns, 2003, p99)*

It is acknowledged that this relativistic approach, the belief that there are a number of truths and not only one truth, is an alternative approach to workplace research. The traditional approach to office productivity has tended to view office productivity as an objective reality.

> *"In essence, social and organizational reality exists independently of human consciousness and cognitions." (Johnson & Duberley, 2000, p 78)*

This study will adopt a similar stance. However, it is intended that some of the components of office productivity will relate to the behavioural environment thereby establishing the existence of a social context (Fleming, 2004).

To progress the research agenda there is a requirement for researchers, in this developing area of workplace research, to publish their research findings so that the research community can make evaluations. Adopting such a strategy allows workplace research to make additions to the knowledge base. Examples of such publications, which demonstrate research rigour, are starting to reach the FM community (Pinder *et al*, 2003;Ilozor, Love & Treloar, 2002; Haynes & Price, 2004)

Therefore, since this research is more interested in establishing a practical way of understanding reality, then it probably falls more into the general area of realism and more specifically critical realism.

Critical realism can be defined as:

> *"Critical realism is a specific form of realism whose manifesto is to recognise the reality of the natural order and the events and discourses of the social world and holds that 'we will only be able to understand - and so a change - the social world if we identify the structures at work that generate those events and discourses." (Bryman, 2001, p13)*

3.2.2 Epistemology

To establish the appropriate epistemological assumption, it is worth identifying the central issue of epistemology, which is: what is regarded as acceptable knowledge within a discipline? (Bryman, 2001). To answer this question, in the context of workplace research, it is worth establishing what constitutes valid knowledge.

Burrell and Morgan (1977) address the epistemological issue by referring to it as the anti-positivism/positivism epistemological debate.

The positivist standpoint proposes that causal relationships and regularities can be established in the social world. Positivists maintain that by the use of objective sense data an empirical world can be established that represents the social world. The positivist view is that valid knowledge is only created when a phenomenon can be observed and measured (Hussey & Hussey, 1997).

The anti-positivist, or the social constructionist, view is that the social world is far too complex to be able to generate predictive laws. No single truth exists, and understanding of the social world is made up of many different truths. The understanding of social contexts can only be understood from within that context. This view clearly requires the researcher to be reflexive within the research process, and therefore the positivist claim that the researcher can remain objective is rejected.

To determine the most appropriate epistemological stance it is worth addressing the purpose of the knowledge created. Habermas (1972) attempts to categorise the different types of knowledge into three main forms; those being technical knowledge, practical knowledge and emancipatory knowledge. The three types of knowledge, and their main purposes, have been summarised by Mingers (1992) (Table 3:1).

Table 3:1 The three knowledge-constitutive interests (Adapted from Johnson & Duberley, 2000, p120)

Type of Science	Cogitative Interest	Social Domain	Purpose
Natural science (Empirical-analytical)	Technical	Work	Prediction Control
Cultural science (Hermeneutics)	Practical	Language/culture	Understanding/ Consensus
Critical science	Emancipatory	Power/authority	Enlightenment

Technical knowledge can be defined as the traditional scientific form of knowledge. This type of knowledge consists of causal relationships with the purpose of offering explanations, i.e. positivism. The methods used to create work knowledge would be empirical-analytical.

Practical knowledge enables an understanding or an interpretation of the topic area to be obtained. The aim is to create meaning rather than causality, and accepts that the individual, i.e. the researcher, cannot be removed form the social context that is being investigated.

Emancipatory knowledge is created by self-reflection. This allows previous contributions to knowledge to be reassessed, and any corrections to be made, i.e. to remove any "wrong" knowledge. This type of knowledge is generated by critical theory methods.

A review of the different kinds of knowledge, and their different purposes, indicates that the knowledge created by researching the effect of the office environment on the office occupiers tends to fall between the technical knowledge and the practical knowledge categories, although it is probably closer to the positivist research epistemology. Whilst positivism appears to be the general categorisation for this type of research, it would be unsafe to class this research as classical positivist research[14]. Since this research does not claim to establish the ultimate truth pertaining to office productivity, but merely a practical way of understanding it so that office environments can be created to enable productive workers.

> *"Positivists take the view that the scientist's conceptualization of reality actually directly reflects that reality, realists argue that the scientist's conceptualization is simply a way of knowing that reality."(Bryman, 2001, p13)*

Whilst this section has aimed to discuss the epistemological stance of this research, it has used the extreme epistemological stances to demonstrate the differences in view points. This research will be based on a positivist epistemology simply because it provides a practical way of establishing an understanding of office productivity.

3.2.3 Human interest

The voluntarism-determinism assumption of the human nature debate tends to revolve around peoples' ability to demonstrate free will (Burrell & Morgan, 1979). The determinism stance proposes that it is the external environment that determines human behaviour. Effectively the external environment directly acts as a stimulus to affect human behaviour. In contrast the voluntarism stance suggests that humans do not have to be dependent on, or victims of, their external world. They can choose, by the use of their free will, the extent to which external events affect their behaviour.

[14] This issue will be revisited in the further research section in chapter 6, where proposals for a mixed approach will be developed.

> *"Insofar as social science theories are concerned to understand human activities, they must incline implicitly or explicitly to one or other points of view, or adopt an intermediate standpoint which allows for the influence of both situational and voluntary factors in accounting for the activities of human being." (Burrell & Morgan, 1979, p6)*

To make the voluntarism-determinism assumption explicit; it is worth revisiting the proposition of this research, which is: to establish the effects of the office environment on the productivity of the office occupiers. An evaluation of this proposition would suggest that it infers the office environment will affect office productivity. Therefore in answer to the human nature debate, it is suggested that this research adopts a deterministic stance with regards to human behaviour.

It could be argued that much of office environment research has adopted a similar stance. Although this approach, taken to extremes, can be seen as a weakness, with prescriptive office environments for predetermined work patterns, (Laing *et al*,, 1998). To address this limitation, this research will adopt the occupier perspective (Fleming, 2004). It is intended that by adopting such an approach a greater appreciation of the behavioural environment will emerge (Wells, 2000; Nathan & Doyle, 2002).

3.2.4 Methodology

This section aims to review the alternative approaches to the undertaking research, and to establish a congruence between philosophical underpinnings of this research through to data collection and analysis (Hussey & Hussey, 1997).

The two extreme ends of the methodological spectrum can be classified as ideographic and nomothetic (Burrell & Morgan, 1979). The ideographic stance maintains that to truly understand social life the researcher must be part of the phenomena under investigation. It is only by seeing the world from the subject's standpoint that real understanding can be achieved (Cairns, 2003). The ideographic view is that the researcher has to be part of the research and offer interpretations of their investigations. There may be no clear aim of the research, but merely to let the research "unfold". It is the process of research that is valued as much as the end product of the research. It is this directionless approach to research that the nomothetic stance takes issue with, since it lacks, what the nomothetics would call, scientific rigour. Since the nomothetic stance requires the research to comply with strict evaluation criteria. The criteria generally used to evaluate research findings are internal validity, external validity[15] and reliability (Gill & Johnson, 2002).

Table 3:2 illustrates a comparison of some of the implicit assumptions associated with the extreme methodological stances of nomothetic and ideographic (Gill & Johnson, 2002).

Table 3:2 A comparison of nomothetic and ideographic methods (Adapted from Gill and Johnson, 2002, p44)

Nomothetic Methods Emphasize	Ideographic Methods Emphasize
Deduction	Induction
Explanation via analysis of causal relationships and explanation by covering law	Explanation of subjective meaning systems and explanation by understanding
Generation and use of quantitative data	Generation of qualitative data
Use of various controls, physical or statistical, so as to allow the testing of hypotheses	Commitment to research in everyday settings, to allow access to, and minimize reactivity among the subjects of research
Highly structured research methodology to ensure replicability of research methods	Minimum structure to ensure explanation by understanding (induction), and subjects' interpretational systems are accounted for.

Laboratory experiments, quasi-experiments, surveys, action research, ethnography

⟵ Methodological Continuum ⟶

In exploring the differentiation between induction, the ideographic methodology, and the deduction, the nomothetic methodology, it is worth discussing their relationship with theory. Two terms are often used when relating research to theory; they are "theory-dependent" and "theory-laden" (Gill & Johnson, 2002).

[15] External validity establishes the extent to which the research findings can be generalized.

Theory-laden relates to the position of the researcher relative to the research, or the positionality of the researcher (Silverman, 2000). Sometimes this assumption is termed the axiological assumption, which relates to role of values in the research (Hussey & Hussey, 1997). The criticism of attempting to adopt an objective stance, is that the researcher will always bring some form of bias. The researcher already has an agenda, even if it is not explicitly expressed. In response to this criticism the nomothetic methodology adopts a number of strategies, specifically the use of a highly structured methodology, as a way of ensuring the replicability of the research findings by other researchers. This research will adopt such attention to detail, thereby attempting to remove the possibility of researcher bias.

Theory-dependent relates to the position of the theory relative to the research. In deductive research a conceptual and theoretical position is established, then empirical observations are undertaken as a way of testing the theory proposed. This approach can be viewed as "theory testing", and particular instances can be deduced from the general theory. In contrast, the inductive stance proposes that it is the data collection that is the start of the research process. This approach suggests that theory is generated from the data, any theory must be grounded in the data, and general inferences can be made from the particular instances (Hussey & Hussey, 1997).

Gill & Johnson (2002) have attempted to link the issues of induction and deduction with the learning cycle of human beings (Figure 3.4).

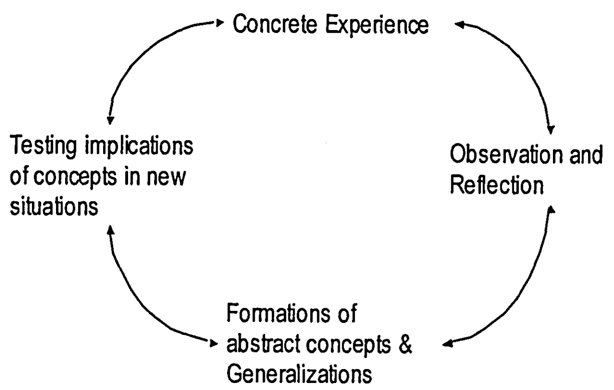

Figure 3.4 Kolb's Experiential Learning Cycle (Adopted from Kolb *et al,* 1970)

According to Gill & Johnson (2002) the inductive process would start with the concrete experiences and then move through to observation and reflection, and finally generalisations of abstract concepts would be derived. In contrast the deductive method starts with the formulation of the abstract concepts and generalisations, then moves to testing the concepts in new situations, with the outcome being new concrete experiences. This cyclical representation of the research process illustrates that both inductive and deductive processes have value, and can complement each other. By adopting this approach the question is not induction or deduction, but where to start the process. This research will start with the formulation of abstract concepts, such as office productivity, and then move on to test the concepts. Therefore this research could be classed as deductive research.

The preceding discussions about the philosophical assumptions have led to the following conclusions. The social world can be investigated in a similar manner as the natural world with a critical realist view on ontology.

> *"For the realist, the social world has an existence, which is as hard, and concrete as the natural world."(Burrell & Morgan, 1979, p 4)*

A positivist epistemological stance can be adopted, as a way of establishing valid knowledge of this "hard" objective social world.

In a practical sense positivism and realism can be seen to share common features.

> *"Realism shares two features with positivism: the belief that the natural and the social sciences can and should apply the same kind of approach to the collection of data and to explanation, and a commitment to the view that there is an external world to which scientists direct their attention (in other words, there is a reality that is separate from our descriptions of it)." (Bryman, 2001, p13)*

In line with realist ontology and a positivist epistemology, a deterministic assumption is adopted in answer to the human nature debate. Therefore to ensure congruency with the decisions of the proceeding philosophical assumptions, the appropriate methodological assumption is the nomothetic methodology.

3.3 Research Design

To assist with the development of the justification, and demonstration of rigour, of research design, a framework of logical structure will be developed. The structure adopted will follow a Hypothetico-Deductive Methodology such as the one proposed by Sekaran (1992).

1. Observation
2. Preliminary Information Gathering
3. Theory Formulation – Theoretical Framework
4. Hypothesis Development
5. Design of Measurement Instrument
6. Data Collection
7. Analysis of Data
    a. Statistical Control & Hypothesis Testing
8. Deduction

Stage 1 of the framework, observation, is established by defining the broad area of research. Hussey & Hussey (1997) would identify this stage as the identification of a research problem. To obtain a valid research problem it is clear that a linkage exists between stage 1 and 2, since stage 2 requires a review of the literature to establish what has already been researched and to establish that the general area of research is worth pursuing. This process is an iterative process with a suitable research problem existing at the end of it (Hussey & Hussey, 1997).

The literature review chapter addresses the initial stages of the framework, with the conclusion that office productivity is at its formative stage of research, and is a worthy area of research activity. Whilst the literature review provides the major justification for the research, it is acknowledged that deductive methodology places less of an emphasis on the source of theories and hypothesis, and more on the logic and rigour of the research process.

> *"To many researchers working within the deductive traditions, the source of one's theory is of little significance (Popper, 1967, pp. 130-43) – it is the creative element in the process of science that is essentially unanalysable." (Gill & Johnson, 2002, p34)*

The remaining stages of the Hypothetico-Deductive methodology will now be discussed in greater detail.

3.3.1 Theoretical framework

The theoretical framework is a graphical representation, which attempts to establish a model for understanding the linkages between theory and the area of research.

> *"A theoretical framework is a collection of theories and models from the literature, which underpins a positivistic research study." (Hussey & Hussey, 1997, p123)*

Previous research, which has attempted to evaluate office environments and their effect on occupiers' productivity, has tended to view the office as a purely physical construct; the physical environment. The discussions have tended to centre on two main areas, those being office comfort (Oseland, 1999; 2004; Leaman & Bordass, 2000) and office layout (Becker & Steele, 1995). A range of different metrics exists to create tangible measures for office comfort and office layout. This approach presumes the occupant to be a passive recipient of the office environment. This view does not acknowledge that the office is a socially constructed environment. Therefore the dynamics, or the flow, of the office is not evaluated (Nathan & Doyle, 2002). It is therefore proposed that it is the dynamic interactive elements of the office environment, the behavioural environment, that enable various forms of communication, and ultimately office productivity. This theory is expressed graphically in Figure 3.5.

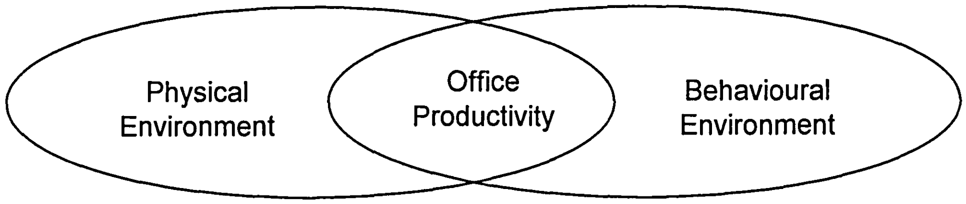

Figure 3.5 Concepts of office productivity

Whilst Figure 3.5 illustrates the general theory that office productivity is a composite of the physical environment and the behavioural environment, a little restructuring is required to enable the derivation of the research hypotheses.

> *"The theoretical framework is a fundamental part of this type of research as it explains the research questions or hypotheses." (Hussey & Hussey, 1997, p123)*

Figure 3.6 attempts to illustrate that office productivity is a composite of the physical and the behavioural environment, and both must accommodate different work patterns to ensure maximum office productivity.

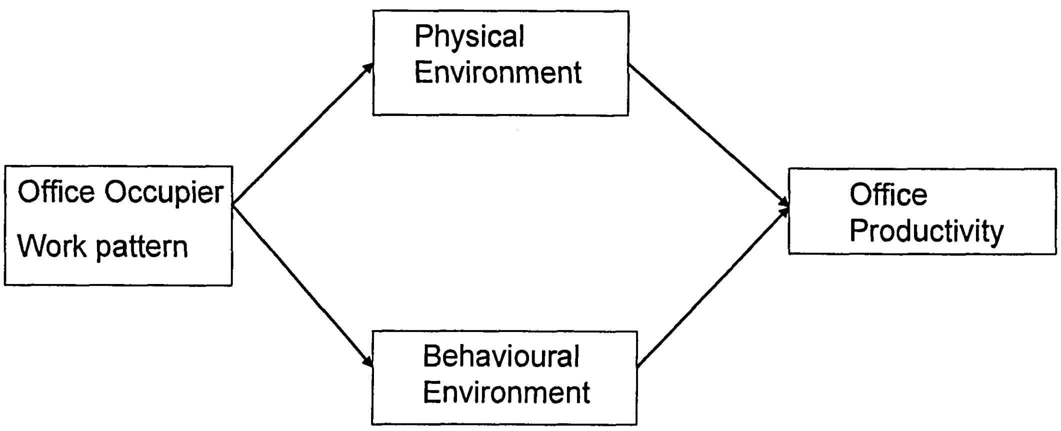

Figure 3.6 Theoretical framework of office productivity

3.3.2 Hypothesis development

The first aim of this research is to establish that a model can be developed to represent the concept of office productivity, with the dimensions of physical environment and behavioural environment. This leads to the first testable proposition or hypothesis, which is:

> *Hypothesis One:*
>
> *Office productivity is a composite of the physical environment and the behavioural environment.*

This research aims to establish that it is the different forms of communication, specifically conversation, that are the currency of a productive office.[16] Therefore it will be factors that enable interaction to occur, that will be seen as the factors that have the most positive impact of on office productivity.

> *Hypothesis Two:*
>
> *It is the behavioural components of office productivity that have a greater effect on productivity than the physical components.*

The final hypothesis aims to establish if office occupiers, who adopt different work styles, can be segmented based on differences of perceived office productivity with regards to the physical environment and the behavioural environment.

> *Hypothesis Three:*
>
> *There is no significant difference between work patterns in terms of office productivity.*

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[16] The notion that conversation is the currency of the modern organisation is accredited to Price and Shaw (1998)

Whilst the creation of a theoretical framework, and subsequent hypotheses, are the start point of the research process there is a requirement, within the positivist methodology, to demonstrate rigour and attention to detail in the design and application of the research process.

> *"What is important in 'science' is not the sources of the theories and hypotheses that the scientist starts out with, rather it is the process by which those ideas are tested and justified that is crucial." (Gill & Johnson, 2002, p39)*

To comply with the strict requirements of a positivistic methodology detailed attention will be paid to the justification, logic and rigour of the research design, administration and analysis.

The next section will address the specific issue of justifying the design, and appropriateness, of the research measurement instrument.

3.3.3 Design of measurement instrument

To illustrate the appropriateness of the research design, and the subsequent research instrument, Figure 3.7 illustrates the range of philosophical and design options available[17] (Easterby-Smith *et al,* 2002). Easterby-Smith *et al* (2002) use the horizontal axis to illustrate the different philosophical stances, with the extremes of positivism and social constructivism. The horizontal axis represents the relationship between the researcher and the subject of the research. This could be considered as the researcher position (Gill & Johnson, 2002). The researcher position ranges from the researcher being totally immersed and involved in the development of the research, to the researcher being totally objective and detached from the research.

[17] It is acknowledged that there are numerous ways in which research can be classified.

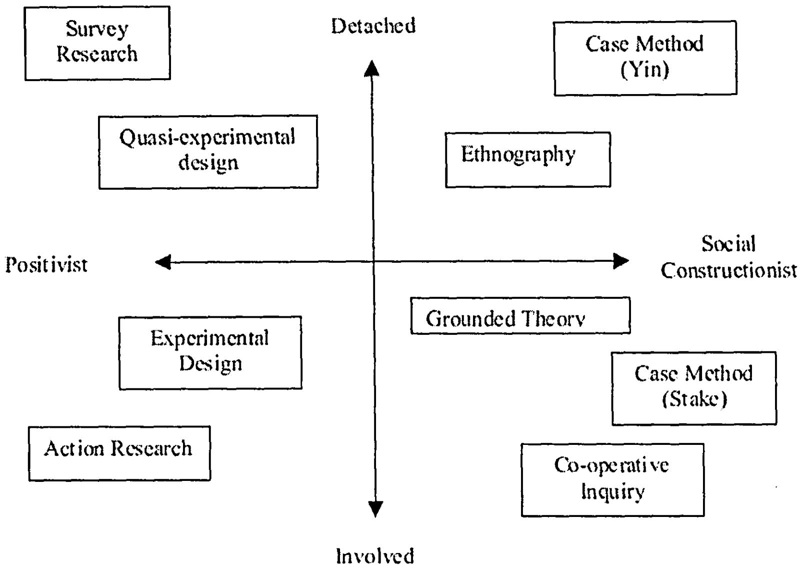

Figure 3.7 Matrix of alternative research designs (Adapted from Easterby-Smith *et al*, 2002, p57)

In line with the nomothetic methodology, it would seem appropriate to adopt a research design that is in the top left quadrant of the research matrix by Easterby-Smith *et al* (2002). Gill and Johnson (2002) support the survey and quasi-experiment as viable options for a nomothetic research design.

Therefore, the choice of research design appears to be between the research survey and the quasi-experimental design. The aim of quasi-experimental research is to compare the behaviour between two different groups, one who had experience of the phenomena under investigation, and one who had no experience of the phenomena (Gill & Johnson, 2002). Since this research is at the formative stages of workplace research, and is in part exploratory in nature, such as establishing the components of the general concept of office productivity, it appears more appropriate to adopt the research survey as the research design.

> *"A survey is a positivistic methodology whereby a sample of subjects is drawn from a population and studied to make inferences about the population." (Hussey & Hussey, 1997, p63)*

There are two general categories of survey, the descriptive survey and the analytical survey (Hussey & Hussey, 1997). The descriptive survey aims to establish frequencies of occurrence, and is useful in establishing views of employees of an organisation. In contrast the analytical survey aims to establish relationships between variables contained within the survey. This research will be mainly an analytical survey, since initial analysis aims to establish the sub components of office productivity and their correlated variables.

Having established that a survey is the most appropriate research design, it is also important to be explicit about the unit of analysis and the respondents of the survey. A respondent is the person who actually responds to the survey and in this instance the respondent is the occupier of the offices under investigation. The unit of analysis is usually selected at the lowest level as possible (Kervin, 1992 as cited in Hussey & Hussey, 1997). The advantage of a low level of unit of analysis is that it may be aggregated to establish another unit of analysis. In this research data is collected at the individual level, the office occupier, but aggregating the data allows different units of analysis to be created, such as components of office productivity or the work pattern of the office occupiers[18]. Unfortunately the reverse is not true and any attempt to draw conclusions about individuals based on data about groups would be an error of reasoning called "The Ecological Fallacy".

> *"The ecological fallacy is an error of assuming the inferences about individuals can be made from findings relating to aggregate data." (Bryman, 2001, p207)*

Whilst the research survey appears to be the most appropriate research design for this research it should be acknowledged that there are a number of criticisms of surveys as a research design (de Vaus, 1999).

1. Surveys cannot adequately establish causal connections between variables. This research does not make causal connections as it asks the respondent to make the connection between the office environment and productivity. It is

[18] These units of analysis will be developed further in subsequent chapters

therefore acknowledged that this research does not claim to establish a closed system and therefore remains an open system (Johnson & Duberley, 2000).

2. Surveys seem to assume that external forces determine human action and neglect the role of human consciousness. This has already been addressed under human nature. This research adopts a deterministic assumption that the office environment has an affect on occupiers' productivity.

3. Survey research is equated with a sterile, ritualistic and rigid model of science centred around hypothesis testing and significance tests, which involves no imagination. This criticism underestimates the creativity involved in establishing a new hypothesis to be tested in the first place.

4. Survey research is basically empiricist. That is, it merely collects a mass of facts and statistics and provides nothing of theoretical value. This would be true if a theoretical structure had not been established before the design of the research. This research has established a theoretical framework, which allows linkages between the theory and research to be established.

5. Some things are not measurable – especially by surveys. This criticism will be addressed later in this section on research design, since the concept of office productivity will be operationalised, thereby enabling it to be measured.

6. Surveys are too statistical and reduce interesting questions to totally incomprehensible numbers. Whilst there may be a temptation to apply every statistical technique, the next two chapters will rationalise the use of the statistical techniques used, and more importantly offer an interpretation of their meaning in the context of office productivity.

Since this research aims to establish a practical appreciation of office productivity, it seems appropriate to undertake a cross-sectional survey, which allows a sizable data set to be collected relatively quickly and cheaply.

> *"A cross-sectional design entails the collection of data on more than one case (usually quite a lot more than one) and at a single point in time in order to collect a body of quantitative or qualitative data in connection with two or more variables (usually many more than two), which are then examined to detect patterns of association." (Bryman, 2001, p41)*

Whilst a cross-sectional design does not allow comparison of data over time, it does allow for comparisons to be made between different subgroups of a sample data set. This is specifically relevant for this research as it allows comparisons between different work patterns to be made.

Data Collection Techniques

Having determined that the cross-sectional research survey is the most appropriate research strategy, the next design decision entails establishing the most appropriate data collection technique. The three main survey data collection techniques to be considered include questionnaire by mail, face-to-face structured interview and telephone interview. Each of the three data collecting techniques has advantages and disadvantages, and using the following criteria of assessment, de Vaus (1999), the relative pros and cons will be discussed.

1. Response rates
2. Ability to produce representative samples
3. Limitations of questionnaire design
4. Quality of responses
5. Implementations problems

The response rates of telephone and questionnaires have traditionally been viewed as being weaker than face-to-face interview response rates. The benefit of a face-to-face interview is that the interviewees will have has already undergone a preliminary screening by consenting to be interviewed. Therefore, since the interviewees will have been pre-warned about their inclusion in the survey, there is less likelihood of refusing an interview when the interviewer arrives at the respondent's location.

Whilst a questionnaire may be targeted at a certain respondent, to try to ensure a representative sample is achieved, ultimately there is no control of who actually fills in the questionnaire, apart from asking for the questionnaire be passed onto the appropriate person. In contrast, due to the fact that the researcher is actively involved in the research process for face-to-face and telephone surveys, clarification can be sought at the outset as to the appropriateness of the respondent.

The face-to-face interviewer has the most flexibility in questionnaire design, since the interviewer can adapt the questions in response to the feedback from the respondent. The same could be said of the telephone survey, although the face-to-face interviewer is more likely to develop a better rapport. Both the face-to-face interviewer and the telephone researcher can follow up any questions, thereby avoiding non-completion of questions. It could be argued that this is intervention by the researcher, and therefore corrupts the researcher's claims to objectivity. Also, by allowing the researcher the opportunity to adapt to the respondents, there is the possibility that the rigour of standardisation of a positivist research methodology is undermined.

When it comes to obtaining quality answers (accurate answers) the mail questionnaire is the best. If the respondent fills in the questionnaire independently, then they are more likely to respond honestly to controversial issues. It should also be noted that the very involvement of a person in the research process could potentially influence the outcome. An example of this is the personal characteristics of the interviewer, such as gender and age, affecting the way the respondent responds to the questions.

When it comes to the implementation of the survey there are a number of problems associated with the face-to-face interview. The first problem relates to the suitability of the research staff, such as do they have the required experience to conduct personal interviews? Also, if a number of interviewers are used, either face-to-face or individual, a problem with regards to consistency emerges. The face-to-face interviewer must travel to the respondent's location, which can be costly and time consuming. In terms of speed of responses, the most effective method is the telephone, although the number of responses may be more limited in comparison to the responses that can be achieved by mail questionnaire. In terms of cost the face-to-face method is the most expensive and the mail questionnaire the least expensive.

The relative advantages and disadvantages of the data collection techniques can be summarised as follows. The face-to-face interview performs best when it comes to obtaining response rates, a representative sample and overcoming the effects of questionnaire design. However in terms of the quality of the questions and the issues of implementing the survey the face-to-face interview appears to be worse than both the telephone interview and the mail questionnaire. In fact the mail questionnaire produces the best quality of questions, and has least problems with regards to implementation (de Vaus, 1999).

Developing indicators for concepts

Having established that the research survey, using a questionnaire, is the most appropriate research design, there is a requirement to develop the design from the macro level to more the micro level of research design. This process involves the development of the abstract concepts, used in the theoretical framework and hypothesis, into measurable empirical indicators (Coolican, 1999). This process is known as operationalization (Gill & Johnson, 2002).

Adopting a deconstruction process can assist in operationalizing abstract concepts into measurable indicators. A three-stepped approach can be used to translate concepts into indicators (de Vaus, 1999).

1. Clarifying the concepts;
2. Developing initial indicators
3. Evaluating the indicators

The first part of the process requires that the concepts used in explaining the theoretical framework and the hypotheses are deconstructed to ensure that the meaning behind the concepts are clear and explicit.

> *"Concepts are simply tools which fulfil a useful shorthand function: they are abstract summaries of a whole set of behaviours, attitudes and characteristics which we see as having something in common." (de Vaus, 1999, p48)*

The concepts used in the office productivity theoretical framework, and the hypotheses, include; “physical environment”, “behavioural environment”, and “work pattern”. Therefore for the purpose of this research the concepts can be defined as having the following meanings.

Work pattern relates to the process of work that the office occupier undertakes. It addresses the issue of how people work when they are in the office environment.

Physical environment relates to the tangible elements within the office environment, which can be further sub divided into the dimensions office layout and office comfort.

Behavioural environment relates to the intangible elements within the office. This concept establishes an understanding of the compatibility of people in the office space, i.e. the psychology of work in an office environment.

Figure 3.8 illustrates the redefined concepts and shows the physical environment being further deconstructed to include the dimensions of comfort and office layout.

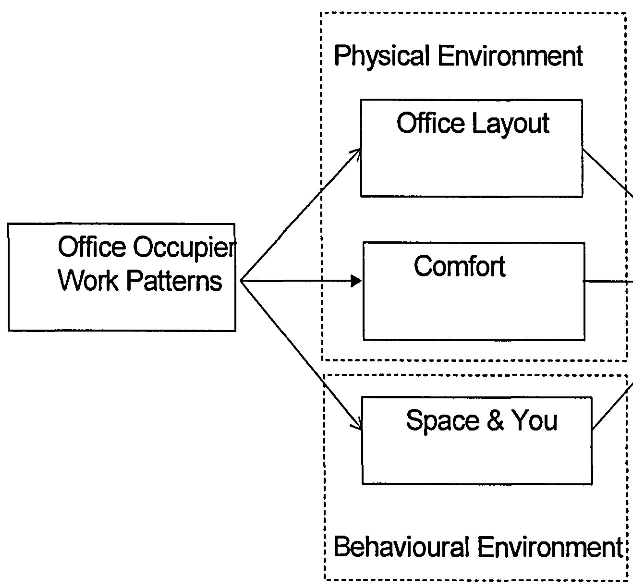

Figure 3.8 Relationship between concepts

Having established meaning to the concepts, and the dimensions, used in this research there is a requirement to further develop the concepts into variables that can be measured, and subsequently included in a questionnaire. This process of moving from abstract concepts to operational measurements is sometimes termed "descending the ladder of abstraction" (de Vaus, 1999, p50).

Table 3:3 illustrates how the dimensions of office layout, office comfort, representing the physical environment, and space and you, representing the behavioural environment, can be deconstructed further to establish 27 evaluative variables[19].

Table 3:3 Operationalization of variables

Office Layout	*Office Comfort*	*Space and You*
Work Area	*Heating*	*Physical Security*
Personal Storage	*Natural Lighting*	*Social Interaction*
General Storage	*Artificial Lighting*	*Work interaction*
Formal Meeting Areas	*Ventilation*	*Creative Physical Environment*
Informal Meeting Areas	*Noise*	*Privacy*
Quiet Areas	*Cleanliness*	*Interruptions*
Circulation Space	*Décor*	*Crowding*
Position of Colleagues	*Overall Comfort*	*Overall Atmosphere*
Position of Equipment		
Refreshment		
Overall layout		

The variables included to represent the dimensions of layout and comfort, which are a measure of the physical environment, are largely derived from established office literature (Becker & Steele, 1995; Laing *et al,* 1998; Oseland & Bartlett, 1999; Leaman & Bordass, 2000). The variables for the space and you concept aim to measure the behavioural environment (Bitner, 1992: Wells, 2000). Each of the office environment concepts contains a marker indicator, such as overall layout, overall comfort, and overall atmosphere. The marker indicators are used during the analysis stage, to ensure that all multiple-indicators are correlated together. The technique provides confirmation that the multiple-indicators are measuring the relevant concept under investigation.

[19] This deconstruction is largely a product of the literature, and the requirement to better understand the behavioural environment.

The concept work pattern requires an understanding of how people work in the office environment, and can operationalised by including variables that measure the following:

1. Amount of interaction with colleagues

2. Autonomy to work flexibly

3. Variety of task undertaken when in the office

4. Time spent in the office

The first three variables were taken from previous office research, as an established way of categorising office occupiers into different work patterns (Laing *et al*, 1998). By adopting similar work pattern categorising variables, subsequent analysis can compare and contrast findings from this research with those of previous studies.

Multiple-indicator measures were adopted for each of the concepts under investigation, as a way of addressing the problems associated with using a single indicator (Leaman & Bordass, 2000, Olson, 2002). If a single indicator is used there is the possibility that the validity of responses may be threatened, due to the respondent misunderstanding the question (Bryman, 2001). These problems can be overcome by the use of multiple-indicators, due to the averaging effect. Another limitation of single indicators is that they may only measure part of the concept. Therefore part of the detail of understanding the concept will be lost. A multiple-indicator offers the possibility of a fuller appreciation of the concepts under investigation.

The adoption of the positivist methodology requires attention to criteria of assessment of the research design. Therefore to address these issues this section aims to establish how the criteria of reliability and validity are dealt with within this research design.

The real acid test for reliability is whether or not another researcher can undertake the same study, adopt the same design and produce the same results as the original study.

> *"Reliability refers to the consistency of a measure of a concept." (Bryman, 2001, p70)*

Therefore, the key to ensuring reliability is a systematic and detailed explanation as to how the research was undertaken. This chapter aims to make explicit all issues of research design; application and analysis in an attempt to demonstrate how the procedures adopted have been made as operational as possible, thereby attempting to remove any variation.

Bryman (2001) proposes that the criteria of assessment to be addressed, with regards to reliability, are stability, internal reliability and inter-observer consistency. Each of these criteria will now be discussed as a way of demonstrating how this research complies with the requirement for reliability.

The main objective of demonstrating stability is to demonstrate that the concepts under investigation are consistent over time. Traditionally the method for testing stability is the *test-retest* method. This method requires data to be collected on two different occasions, from the same sample, separated by a time period. The requirements for this research design were for a cross-sectional survey and therefore did not provide the opportunity to revisit the same sample. However an opportunity did exist to test the stability of the concepts created with another sample.[20] Whilst the sample was not the same as the original, the observations were separated by a time period of approximately 30 months; therefore it could be argued that the confirmation of the concepts over such a period of time demonstrated the consistency of the concepts under investigation, and also the possibility of a wider application of the concepts.

When multi-indicator measures are adopted, as in this research, it is essential that the indicators are assessed to confirm that there are measuring the concepts they are supposed to be measuring.

> *"When you have multiple-item measure in which each respondent's answers to each question are aggregated to form an overall score, the possibility is raised that the indicators do not relate to the same thing; in other words, they lack coherence." (Bryman, 2001, p21)*

[20] Further information about the second sample will be discussed later in section 3.3.4.

To demonstrate internal reliability of this research, Cronbach's alpha tests were applied to all concepts. The Cronbach's alpha result ranges from 0 to 1. A 0 result would indicate no internal consistency between the multiple-indicators and a result of 1 would indicate complete internal consistency. An acceptable value of Cronbach's alpha can vary with different writers proposing different levels of acceptance. Bryman (2001) proposes that a Cronbach's alpha of 0.8 should be adopted as a rule of thumb guide of acceptance. In contrast Hair *et al* (1995) propose that a Cronbach's alpha of 0.7 should be adopted, but acknowledge that in exploratory social science research, an acceptance value of 0.6 could be adopted. It should be noted that if the Cronbach's alpha value does not reach an acceptable level, then it can be improved by increasing the number of indicators measuring the concept (de Vaus, 1999).

The final consideration for reliability is inter-observer consistency, which is concerned with the variation that may be introduced if the research involves a number of different observers. Since the author undertook the analysis and interpretation of this research, then it is claimed that this measure of consistency has been achieved.

Throughout the rest of this thesis the issues of reliability, specifically stability and internal reliability, will be addressed with the aim of demonstrating the robustness of the research design. Also further threats to reliability will be addressed such as ambiguity in the survey questions, leading to different interpretation and response, and the consistency of the research process. It will also be demonstrated that the inclusion of a pilot study increases the reliability of the research process and that of questionnaire design.

Having established a number of concepts and developed a number of indicators as a means of assessing those concepts, it important to demonstrate their validity.

> *"Validity refers to the issue of whether an indicator (or set of indicators) that is devised to gauge a concept really measures that concept." (Bryman, 2001, p72)*

Therefore, the criteria of validity are very much dependent of how well the measures chosen in the research design, actually measure the concepts under investigation.

Validity can be measured in a number of different ways, therefore each of the main ways of accessing validity will now be discussed as a way of demonstrating the validity of this research.

To demonstrate face validity, the research instrument, in this case a questionnaire, needs to look as though it is measuring what it purports to measure. This can be achieved by presenting the questionnaire to a panel of experts to establish their thoughts on how well the indicators, on face value, measure the concepts (de Vaus, 1999). A panel of experts, which consisted of a number of colleagues in the Facilities Management Graduate Centre (FMGC), was used in this research during the piloting stage of the questionnaire design.

Content validity relates to whether the concept under investigation, in this case office productivity, is fully measured; are all the dimensions of office productivity included? This is a difficult aspect of validity to totally demonstrate compliance with, since the measure of the concept will always be limited to the number of questions included about the concept. There is the possibility that other dimensions of office productivity have not been included.

This is a limitation of content validity that ultimately puts greater emphasis on the research design.

> *"Whether we agree that a measure has content validity depends ultimately on how we define the concept it is designed to test." (de Vaus, 1999, p56)*

Since this research is exploratory in nature, and the concepts and dimensions have been designed specifically from the theoretical framework, it is claimed that evaluating the research design can be the only way of assess content validity. In this context it is claimed that content validity is achieved, although it is acknowledged that office productivity could always be operationalised differently.

Criterion validity is fundamentally concerned with how well the measures developed relate to other measures previously investigated. It has been previously established that the indicators used in the dimensions of office layout and comfort are largely derived from established workplace literature. The work pattern indicators were derived from research by Laing *et al* (1997). Therefore for these dimensions criteria validity is claimed, although it must be acknowledged that no other research has linked these dimensions to productivity in the way that appears in this research. It is also acknowledged that the indicators used in the measurement of the behavioural environment have not been used previously to measure the behavioural environment dimension, since this is a completely new dimension under investigation.

Construct validity is a test to assess if the concepts and dimensions established in the theoretical framework perform as hypothesised.

> *"This approach evaluates a measure by how well the measure conforms with theoretical expectations." (de Vaus, 1999, p56)*

The construct validity of this research will be constantly assessed during the subsequent analysis sections, since comparisons will be made between the hypotheses stated at the outset of the research, and the actual outcome of the research. It is important to establish the verification of hypotheses, since hypotheses that are not verified could be an outcome of two possibilities; either the theory used was misguided, or the measures used to measure the concept were invalid (Bryman, 2001). Determining which of the two options to be the cause of failed hypotheses can be especially difficult with new measures, since it is difficult to establish whether a misguided theory or a poor measure of the concept is to blame (de Vaus, 1999). To increase construct validity attention has been paid to demonstrating the operationalization of the measures used, thereby strengthening the case for correct use of measures and minimising the case for use of misguided theory.

The demonstration of causality is a usual preoccupation with quantitative researchers, especially ones adopting a positivist epistemology (Bryman, 2001). The validity criterion adopted to assess the causal relationships between variables is termed internal validity.

> *"This criterion refers to whether or not what is identified as the 'cause(s)' or 'stimuli' actually produce what have been interpreted as the 'effects' or responses'." (Gill & Johnson, 2002, p163)*

A typical research design would aim to measure an independent variable and a dependent variable separately. Then through the use of correlation of the two variables attempts would be made to demonstrate that variations in the dependent variable were the effect of variations in the independent variable (de Vaus, 1999). Adopting this approach aims to create evidence to support the notion that the one variable has caused an effect on another. The strength of internal validity is very much dependent on the researchers ability to remove other competing explanations for the cause and effect produced. This usually requires that extraneous variables, other possible causes, are incorporated into the research so that they can be later discarded as alternative explanations.

In this research the independent variable can be seen as the office environment, and the dependent variables could be considered as the concept office productivity. However this research does not use a separate measure of productivity, but asks the respondents their perception of their productivity. This approach has the benefit of allowing the respondent to make any correlations, if any exist, between office environment and productivity. It could be argued that this increases the claims for internal validity, since the respondent is directly asked about the effects on their productivity caused by the office environment. A similar debate is mirrored in the marketing literature with regards to customer expectations, where researchers adopt either a disconfirmationist or a perceptionist stance (Robledo, 2001). The disconfirmationists adopt the school of thought that separate information is collected about importance and satisfaction, and then correlations are made to establish service performance. The most notable model adopting this strategy is the SERVQUAL model (Parasuraman, Zeithaml & Berry, 1985). In contrast Cronin and Taylor (1992) present a perceptionist model, called SERPERF, which proposes that variables relating to performance must be asked directly (Cronin Jr & Taylor, 1992). Whilst there is much debate as to the most appropriate way of evaluating service performance, with authors arguing the merits of one model over another, it is clear that no real winner can be established. Therefore it is argued that the perceptionist approach is just as valid an approach as any other when it comes to measuring the performance of the office environment in terms of office productivity (Haynes & Price, 2004).

The final validity criterion to be considered is external validity. External validity is the ability to be able to generalise from the sample survey to a wider population.

> *"Generally, this criterion refers to the extent to which any research findings can be generalized or extrapolated beyond the immediate research sample or setting in which the research took place." (Gill & Johnson, 2002, p163)*

The extent to which research findings can be extrapolated and generalised is very much dependent on the sample selection strategy adopted[21]. However it is intended that statistical inferences can be made about the two sample populations. Consideration will also be given to analytical generalisations by combining both the data sets (Yin, 1984).

To demonstrate the robustness of this research design, and the subsequent results, every effort has been made to establish both reliability and validity. However, it is acknowledged that some authors believe that measures should be simply stated, and only minimal consideration given to reliability and validity (Cicourel, 1964 as cited in Bryman, 2001). Bryman (2001) develops the point further by suggesting that in the majority of cases the rigours of validity and reliability are constrained to tests of internal reliability and face validity.

To conclude, this section has demonstrated how indicators can be developed from concepts. Attention has been given to the three-stage process of clarifying the concepts, developing initial indicators and evaluating the indicators (de Vaus, 1999). Generally discussions have included the four distinctive preoccupations of quantitative research, those being measurement, causality, generalisation and replication (Bryman, 2001). The next section will revisit the notion of generalisation by establishing two research populations, and their appropriate sample selection strategies.

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[21] Sample selection will be discussed in greater detail in section 3.3.4.

3.3.4 Sample selection

This section aims to demonstrate the sample selection strategies adopted for the two populations used in this research, with specific emphasis being placed on demonstrating the appropriateness of the sampling techniques adopted. Attention will also be given to generalisation and, just as importantly, the limits of statistical inferences. This latter point is usually a major criticism of statistical generalisations (Bryman & Cramer, 2001).

> *"We should not make inferences beyond the population from which the sample was selected, but researchers frequently do so. The concern to be able to generalize is often so deeply ingrained that the limits to the generalisability of findings are frequently forgotten or side stepped." (Bryman, 2001, p76)*

This research collected data from two different populations. The first population came from the public sector and consisted of local government offices, whilst the second population consisted of a range of offices in a company from the private sector. Since the sampling strategy for the local government and the private sector offices were different, both will now be discussed in greater detail.

Local authority sample

Time and cost restricted the data collection for the local authority project. These constraints dictated what could actually be achieved. This section aims to reflect how the data were collected and what statistical inferences can be drawn.

In total 10 local government authorities took part in the research project. It should be noted that the choice of the 10 authorities was not obtained randomly, since the authorities who participated were part of a research club managed by FMGC at Sheffield Hallam University. It could be argued that this creates an element of bias, since the very fact that the authorities are part of a research club aiming to improve their facilities services differentiates them from other local government authorities.

Therefore, it would be an unsafe assertion to state that the inferences made could be extrapolated to the wider population of local authority offices. It would be a safer assertion to maintain that any inferences to be restricted to the offices involved in this research.

The 10 authorities, by pure chance, happen to be geographically dispersed, and whilst claims of stratification by random selection cannot be made, it can be claimed that the data have an element of geographically stratification.

It could therefore be argued that the sampling strategy adopted for the local authority project was more consistent with convenience sampling. Bryman (2001) proposes that convenience sampling plays a more prominent role in the field of organization studies than is usually acknowledged. Bryman (2001) goes further by stating that:

> *"Social research is also frequently based on convenience sampling." (Bryman, 2001, p97)*

Howitt & Cramer (2000) make a similar point by claiming that most psychology research is opportunistic, and therefore not random but they claim that it is the relationship between variables that is important, not the accuracy of generalisation to the population.

> *"Generally in psychology the choice of sample tends to be opportunistic using convenient groups of people. This is often acceptable because psychologists tend to assume that their theories and ideas apply to people in general. As a consequence, it would not particularly matter who is in the sample. " (Howitt & Cramer, 2000, p84)*

Having accepted the limitations of the sampling strategy used, the question then becomes what can be made of the data obtained. The following table illustrates the questionnaire responses (Table 3:4).

Table 3:4 : Local authority questionnaire response rates

Authority	No of Offices	Frequency	People in Offices	Response Rate
A	4	32	1200	2.7
B	1	29	30	96.7
C	1	35	60	58.3
D	1	45	80	56.3
E	3	88	148	59.5
F	3	107	580	18.4
G	2	48	95	50.5
H	6	416	1354	30.7
J	4	191	605	31.6
K	1	5	186	2.7
Total	**26**	**996**	**4338**	**23**

Table 3:4 identifies the response rates as percentages. These rates indicate how closely the data represent the offices. The total response rate for the survey was 23%. This figure is relatively high in percentage terms and also in terms of absolute value with the number of responses being 996.

The authorities with low response rates were initially followed up, with a phone call, to try to obtain further questionnaires but with only a limited amount of success. An alternative, or even an additional, strategy to increase response rate would have been to actually visit the offices and collect the questionnaires manually. Whilst this would have increased the response rate, and therefore the accuracy, it would have also increased the cost and time to undertake the research. This strategy was ultimately deemed unnecessary; with 996 respondents it was deemed that the increased time and effort to increase the response rate could not be justified in terms of increased precision.

> *"However, by and large up to a sample size of around 1,000, the gains in precision are noticeable as the sample climbs for low figures of 50, 100, 150, and so on upwards. After a certain point, often in the region of 1,000, the sharp increases in precision become less pronounced, and, although it does not plateau, there is a slowing down on the extent to which precision increases (and hence the extent to which the sample error of the mean declines.") (Bryman, 2001, p95)*

So that the inferences drawn from the sample data are accurate, it is important to be clear about the definition of population. In the context of this research the population to which the sample data can be inferred is population of 4,338 Local authority office workers.

Whilst claims cannot be made that the results are statistically representative of local authority offices, as a population, the pioneering aspect, and strength of the research, lies in the fact that the research has been conducted effectively 26 times, each office representing a new population. The aim was to identify consistent correlations and add strength to the claim that the research offers an explanation as to the effects of the office environment on office worker performance.

Private sector company sample

To test the theories that had been developed from the local authority dataset in another context[22], data were collected from a private sector organisation. This additional dataset was collected as part of a commercial contract. Whilst the productivity component was the major part of the research, there were other areas of investigation included in the contract. Having acknowledged this fact, the same survey instrument was used as in the local authority project.

The private sector organisation required an evaluation of the effects on perceived productivity of the office environment. The offices under investigation were the organisation's head offices, which consisted of four main office buildings. The contract research required a compare and contrast evaluation of the four office buildings to establish the most productive office.

Once again, to establish an appropriate sampling strategy, it is worth being totally explicit about defining the population and the sample in this context. The population, in the private sector company, was the 800 head office staff. Therefore, any statistical inferences made from the sample data is to this population.

Since the research was arranged on a commercial basis, additional funds were available which allowed the development of the questionnaire used in the local

[22] This method has been applied in a number of other contexts. This will be developed further in chapter 6.

authority project to be converted into an online questionnaire. The aim was to reduce the time required to administer the questionnaire.

Table 3:5 illustrates the response rates for the four offices under investigation.

Table 3:5 Private sector company questionnaire response rates

Office	Frequency	People in Office	Percentage Response
1	125	200	63
2	105	200	53
3	55	200	28
4	137	200	69
Total	**422**	**800**	**53**

It can bee seen that three of the four offices have response rates above 50%, with two offices having responses above 60%. The total response rate for the survey was 53%. This figure is relatively high in percentage terms and also in terms of absolute value with the number of responses being 422. In comparison to the local authority response total rate (23%) it can be seen that the private sector response rate (53%) is a great improvement. The main reason for the high response rate could be attributed to the use of an online questionnaire.

Since every employee in the head office was sent an email about the questionnaire, and therefore every one had an equal opportunity of being included in the sample, it could be claimed that a fundamental requirement of a simple random sample has be met (Coolican, 1999).

It is important to make explicit the limits of any generalisations of the research findings for the private sector company. The findings cannot be seen as representative of the private sector as a whole. However the findings established from the sample can be used as representative findings for the private sector company head office.

3.3.5 Questionnaire design

It is now appropriate to justify the design of the main data collection technique used in this research, the questionnaire. This section aims to explain the structure of the questionnaire and the rationale as to the types of questions used in the questionnaire. The questionnaire used can be seen in Appendix B.

The first section of the questionnaire introduces the research and provides terms of reference for the respondent. This section is important as it is at this stage that the respondent will determine if they are going to fill in the questionnaire. Hussey and Hussey (1997) propose that the first general rule of designing questions is to:

> *"Explain the purpose of the interview or questionnaire to all participants." (Hussey & Hussey, 1997, p165)*

The questionnaire introduction clearly establishes:

- The research is undertaken by Sheffield Hallam University; and
- Information gathered will be confidential.
- A brief description of the research is given to ensure the respondent understand the aims of the research.
- How the questionnaire should be filled in
- The date the questionnaire should be filled in by.

The sections titled "general" and "about you" aim to establish background information about the respondent, and could be classed as classification questions (Hussey & Hussey, 1997).

> *"Classification questions are questions which set out to find out more about the participant; for example, his or her age and occupation." (Hussey & Hussey, 1997, p171)*

Hussey & Hussey (1997) identify that some authors prefer to put classification questions at the beginning of the questionnaire, whilst some prefer to put them at the end. The rationale for putting them at the beginning, which is how this questionnaire is designed, is to develop the respondent's confidence, thereby encouraging the respondent to complete the rest of the questionnaire.

The fourth section of the questionnaire, titled "ways of working", aims to establish the occupier's way of working when in the office. This was established by asking questions about:

- Time spent working with colleagues
- Time spent in the office
- Ability to work flexibly
- Variety of tasks undertaken in the office

It should be noted that the original ways of working questions included questions about autonomy and the amount of interaction people undertook in the office to create comparable results with the New Environments for Working study (Laing *et al*, 1998). However, as a result of piloting the questionnaire, it became clear that asking respondents about concepts such as interaction and autonomy appeared too abstract. Therefore, to ensure that comparable data were achieved the questions were changed to ask about 'time spent with colleagues' as a surrogate for 'interaction' and 'flexibility of working' as a surrogate for autonomy.

Sections five, six and seven of the questionnaire relate to the evaluation of the office environment and therefore can be considered as evaluative questions. The questions asked are basically the same for all the twenty-seven variables.

> *"In your opinion, in your current office environment, what effect do the following elements have on your personal productivity?"*

The aim of using reoccurring questions was to try to remove any ambiguity and ensure that the respondent was clear as to what was being asked of them. The use of multiple measures of the same concept to increase reliability has been mentioned previously (de Vaus, 1999). An argument against this approach could be that the respondent anticipates the next question, and therefore does not really think about what is being asked; the results produced being a "response set" (de

Vaus, 1999). Changing the direction of the questions can reduce the "response set effect". This too has its faults as it could confuse the respondent. It was decided that the format of the questions would remain the same, since only 27 questions were being asked in this format. Also, by keeping the format the same, it could be argued that the questionnaire becomes easier for the respondent to complete.

The section titled "final comments" asks the question:

> *"Relative to other factors that can affect your work performance, how important to you is your physical working environment?"*

This question aims to assess the internal validity of the research, establishing if the respondents actually believe that this research is important and valid. High support in this question also helps to minimize the arguments for competing hypothesis for effects on work performance.

The final section titled "any other comments" is the only open style question giving the respondent the opportunity to make any other comments that they feel have not been addressed elsewhere in the questionnaire.

Closed questions were predominately used in this questionnaire as it aims to establish correlations and hence relationships. Therefore it seemed appropriate to set the questions in a cause and effect format.

To assist with the data entry a five-point Likert scale was used. Generally the options were very negative, negative, neutral, positive, and very positive. Each option was allocated a score:

1 = very negative, 2 = negative, 3 = neutral, 4 = positive, 5 = very positive

Using the score values average values can be established for each variable or statement. Average values above 3 indicate that the office environment is having a positive effect on work performance and average values below 3 suggest that the office environment is having a negative effect on worker performance.

In contrast to the majority of the questionnaire questions, the final question on the questionnaire, was an open-ended question. It was intended that this would be a catchall question, to catch anything that had not been covered in the questionnaire.

> *"Questions may be described as open-ended, where each respondent can give a personal response or opinion in his or her own words." (Hussey & Hussey, 1997, p166)*

The final question aimed to give the respondent an opportunity to express their own view on how they felt their work performance had been affected by their office environment.

To ensure that the questionnaire was robust two piloting techniques were adopted, those being a standard piloting technique, and the use of a panel of expert judges.

The standard piloting technique consisted of distributing draft questionnaires to a sample of the local authority forum members and asking them to comment on the structure of the questionnaire and the questions with regards to appropriateness (validity) and ambiguity (reliability). The draft questionnaire was also piloted in FMGC research unit with people who had an appreciation of the research area to represent a panel of expert judges.

The comments and recommendations obtained from the two piloting techniques were incorporated into the final questionnaire design.

3.3.6 Data collection

Whilst both the local authority data set and the private sector company data set used the same format of questions in the form of a questionnaire, the way that they were administered was different.

The local authority project used paper-based questionnaires, which were sent to a contact within each of the local authorities involved in the project. The contact was asked to distribute the questionnaires to office occupiers, and have them completed and returned by a certain date. A copy of the covering letter can be seen in Appendix C. Once the questionnaires had been completed, they were returned by post and the process of data entry could begin. It must be acknowledged that the scale of entering data from approximately 1,000 respondents had been under estimated, and required more time than had been anticipated. Once the data were in an excel spreadsheet they were coded for use in SPSS. The excel results were transposed into SPSS so that detailed statistical analysis could be undertaken.

In contrast to the local government project, the private sector company project administered the questionnaire online. This had a number of advantages:

i) Do not have to deal with a number of different contacts.

ii) Access to all employees in the head office buildings

iii) Once questionnaire online, data can be instantly collected.

iv) Conversion of data into excel spreadsheet is instantaneous, thereby addressing the data entry problems previously experienced.

It can be seen that the use of the online questionnaire assisted in the sampling strategy, since everyone had a chance to respond, and also the speed of administration. This specifically addressed some of the limitations of the data collected from the local government project.

3.3.7 Analysis of data

The aim of this section is to present an analytical framework for data analysis. The main analytical tools will be explained with a justification, and rationalisation, given as to their appropriateness to answer the research hypotheses. A structure representing the model development and discussion of results can be seen in Figure 3.9.

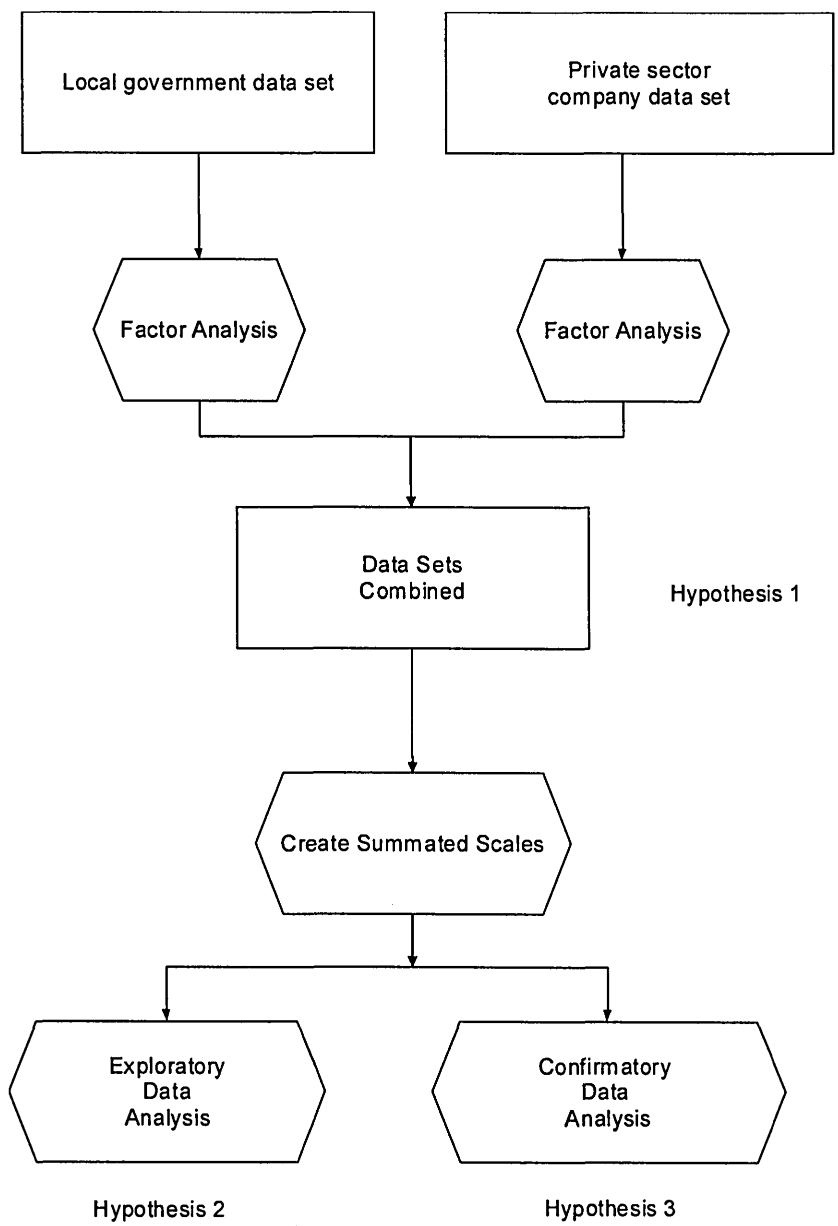

Figure 3.9 Flow chart of data analysis

The first hypothesis to be addressed is hypothesis one

> *Office productivity is a composite of the physical environment and the behavioural environment.*

To evaluate this hypothesis a model of office productivity was developed, and subsequently tested for validity and reliability. The first set of data were collected from the local government project. The data were analysed using factor analysis.

> *"Factor analysis seeks to do precisely what man has been engaged in throughout history, that is to make order out of the apparent chaos of his environment." (Child, 1990).*

Fundamentally factor analysis is a multivariable analysis technique, which aims to establish underlying structure to a given set of data. The aim, in hypothesis one, is to establish the discrete concepts of office productivity. Whilst 27 evaluative variables were used in the research, factor analysis established how the variables were correlated, thereby assessing if the variables were measuring the same concept. Since the questionnaire was designed with multiple-indicators, factor analysis was the chosen method to establish if the multiple-indicators did in fact measure the proposed concepts.

Factor analysis was repeated with the private sector company data set. The reason for repeating the analysis was two fold. Firstly, by undertaking the analysis again the reliability of the results from the local government can be established. Secondly, since the second set of data were collected from the private sector, the possibility existed to establish some form of external validity. It should be noted that great care as to the limits of generalisation have previously been discussed. An additional benefit of repeating the analysis was the ability to improve the administrative elements of the data collection process.

Since both data sets can be generally demonstrated to be measuring the same concepts[23], the two data sets were combined with the result of deducing the concepts under investigation and increasing the robustness of the final concepts developed. At this stage of model development hypothesis one was evaluated, thereby establishing the composite components of office productivity.

Once the underlying concepts of office productivity had been established, it was important to consider how the concepts could be developed to enable the testing of the remaining hypotheses. Therefore, in preparation for subsequent analysis, the concepts developed were converted into scales; summated scales to be more specific. Whilst factor analysis had allowed the underlying concepts of office productivity to be established, it did not establish the measurement of the concepts. Summated scales aim to use the concepts previously derived as a way of creating new composite measures. These new composite measures, or variables, are an average value of the correlated multiple-indicators. Having established a new scale for measurement, comparisons could then be made between the relative values of the composite components of office productivity.

The summated scales created were used to enable relative comparisons to be made between the behavioural and physical components. This analysis allowed the evaluation of hypothesis two. Hypothesis two was defined as:

> *It is the behavioural components of office productivity that have a greater effect on productivity than the physical components.*

The work pattern demographic data were used as a way of subdividing the total data set[24]. Each of the work patterns were evaluated to establish if the behavioural components of office productivity had a greater effect than the physical components. This part of the analysis was termed exploratory data analysis, since

---

[23] With small variations in some of the variables indicating uniqueness of data set.

[24] The work patterns created were based on the four work patterns proposed by Laing *et al* (1998).

exploratory data analysis techniques were used to evaluate the concepts within each of the defined work patterns.

To evaluate the final hypothesis there was a requirement to use the composite components of office productivity as common metrics so that statistical analysis techniques could be applied to the defined work patterns. Hypothesis three was defined as:

> *There is no significant difference between work patterns in terms of office productivity*

The main statistical analysis used in the evaluation of hypothesis three was the ANOVA test. The ANOVA test allows an assessment to be made as to any statistical differences between groups. The groups used in this research being the previously defined work patterns.

3.4 Conclusion

This chapter has presented the research strategy adopted in this study, with special attention given to demonstrating how the philosophical considerations integrate with the research design decisions. Great emphasis has been placed on justification of the philosophical considerations, thereby laying firm foundations on which the research design can be built.

The philosophical considerations discussed led to an objectivist approach to the research. Adopting this philosophical stance requires adherence to a number of underlying assumptions.

The first assumption addresses the ontology of the research. This research has adopted the position that office productivity, as a concept, can be considered as having a reality of its own. In effect office productivity is seen as having an existence that is independent of the office occupiers. Adopting this stance gives this research an ontological stance of realism.

The second research assumption adopted relates to epistemology, establishing what constitutes as acceptable knowledge within a discipline. Whilst the contrasting stances of epistemology were discussed, this research has more of an alignment with positivism than it does the alternative, anti-positivism. Adopting this stance implies that the phenomena under investigation, office productivity, can be measured in the social world through the use of empirical data. This is congruent with an objective reality ontological stance.

The third research assumption to be adopted was that of determinism, which relates to human nature. The proposition of this research is that the office environment has an affect on productivity. Therefore the occupiers' productivity is dependent on their office environment. The linkage between the external environment and its affect on human behaviour place this research in the category of determinism rather than that of voluntarism.

The final philosophical assumption addressed was that of methodology. Having previously established stances with regards to ontology, epistemology and human nature it was important to establish a congruent methodology. The stance adopted was a nomothetic methodology. Adopting this stance required a deductive approach, with great emphasis on structure and the assessment criteria of the research.

The latter part of this chapter has presented the development of the research design, which adopted a hypothetico-deductive methodology. A theoretical framework was presented as a foundation for the development of the research hypotheses. The measurement instrument considered to be the most appropriate to test the research hypotheses was a survey instrument, or more specifically a questionnaire. This chapter concludes with consideration being given to the process of data collection and an outline structure of the data analysis techniques that will be adopted in subsequent chapters.

Chapter 4

Model development

4 Model Development

4.1 Introduction

This chapter aims to use factor analysis to develop a model for office productivity. Factor analysis is used to establish underlying structure to the evaluative variables used in the study. It is intended that this data reduction technique will provide insights into the components underpinning the concept of office productivity. To demonstrate the robust nature of the components created two sizable data sets will be used as the basis of analysis. Both data sets will be compared and contrasted to establish validation of the components created. This approach will enable an evaluation of hypothesis one.

> *Hypothesis One:*
>
> *Office productivity is a composite of the physical environment and the behavioural environment*

Finally, having created components of office productivity, the final sections of this chapter will use a scale development technique to allow quantitative values to be attached to the components for initial and subsequent analysis. The scales developed will be used to evaluate hypothesis two.

> *Hypothesis Two:*
>
> *It is the behavioural components of office productivity that have a greater effect on productivity than the physical components.*

The structure of this chapter can be seen in Figure 4.1.

Section 4.1

Introduction

↓

Section 4.2

Factor analysis

↓

Section 4.3

Objectives of factor analysis

↓

Section 4.4

Designing factor analysis

↓

Section 4.5

Assumptions in factor analysis

↓

Section 4.6

Deriving factors and assessing overall fit

↓

Section 4.7

Interpreting factors

↓

Section 4.8

Validation of factor analysis

↓

Section 4.9

Scale development

↓

Section 4.10

Conclusions

Figure 4.1: Structure of Chapter 4

4.2 Factor analysis

It is important to justify why factor analysis is an appropriate vehicle for multivariate analysis, and to differentiate between dependence techniques and interdependence techniques.

The main aim of this research is to establish underlying structure in the data set so that a conceptual understanding can be achieved. Therefore, exploratory research of all variables must be investigated concurrently. This is an indication that a multivariate interdependence technique is appropriate (Hair *et al,* 1995).

Factor analysis is one of a range of multivariate independence techniques available. The other techniques being cluster analysis, correspondence analysis and multidimensional scaling (Hair *et al,* 1995).

> *"Factor analysis is an interdependence technique in which all variables are simultaneously considered, each related to all others, and still employing the concept of*

> *variate, the linear composite of variables. In factor analysis, the variates (factors) are formed to maximize their explanation of the entire variable set, not to predict a dependent variable(s)." (Hair* et al, *1995, p91)*

In contrast a dependence technique such as multiple regression, discriminate analysis and others, use one or more variables as dependent variables or criterion variables to establish relationships with the independent or predictor variable. The purpose of dependence techniques is to extrapolate from the data predictive relationships, which the researcher can interpret. Hair *et al* (1995) summarise the difference in the purpose of the techniques by labelling dependence technique as "prediction" and interdependence technique as "identification of structure".

Since the aim of this research is to develop an identification of structure, rather than develop predictive relationships, then this supports the use of factor analysis.

To develop a further understanding, and an appreciation of the application of factor analysis, then it would be beneficial to explore a few definitions.

Definitions:

> *"It is a mathematically complex method of reducing a large set of variables to a smaller set of underlying variables referred to as factors." (de Vaus, 1999, p257)*

Whilst this definition by de Vaus (1999) summarises the essence of factor analysis, it does not explain to the researcher the purpose of reducing variables to factors.

Coakes and Steed (2001) confirm factor analysis as a data reduction technique, but extend this definition to include the identification of an underlying structure of the variables.

> *"Factor analysis is a data reduction technique used to reduce a large number of variables to a smaller set of underlying factors that summarise the essential information contained in the variables. More frequently factor analysis can be used as an exploratory technique when that the researcher wishes to summarise the structure of a set of variables."(Coakes & Steed, 2001, p155)*

Coakes and Steed (2001) also propose the nature of factor analysis as being an exploratory technique to enable the researcher to establish an understanding of the underlying structure of the variables.

The definition of factor analysis proposed by Hair *et al* (1995) is probably more explicit than the previous definitions, as it explains how the underlying dimensions or factors are identified, i.e. by inter relationships (correlations) between the variables.

> *"Factor analysis is a generic name given to a class of multivariate statistical methods whose primary purpose is to define the underlying structure in a data matrix. Broadly speaking, it addresses the problem of analysing the structure of the interrelationships (correlations) among a large number of variables (e.g., test scores, test items, questionnaire responses) by defining a set of common underlying dimensions, known as* ***factors."*** *(Hair et al, 1995, p90)*

Factor analysis has two main purposes. These are summarization and data reduction (Hair *et al,* 1995). Using factor analysis to summarize data enables the researcher to condense a larger number of variables into the basic underlying dimensions, i.e. factors. This can be particularly useful if underlying concepts of a phenomenon are to be established. The benefit of being able to reduce a large number of variables to a smaller number of factors, is endorsed by Babbie (1990, p314):

> *"An efficient method of discovering predominant patterns among a large number of variables. Instead of the researcher being forced to compare countless correlations – simple, partial, and multiple – to discover patterns, factor analysis can be used for this task"*

Factor analysis may be used as a means in itself, as in summarization, or as an intermediate stage to further analysis, such as data reduction, Data reduction allows the use of a "substitute" scale. The underlying concepts, dimensions, are represented by the reduced variables, which replace the original variables, while still maintaining the integrity of the original data set.

Therefore having reviewed definitions of factor analysis, it can be concluded that one of the main benefits is that it allows underlying structure of the data to be established. The use of factor analysis allows data to be reduced to separate identifiable dimensions, i.e. factors. An understanding of how the data variables relates to, or are explained by, the factors, enables the researcher to develop a deeper understanding, and develop the interpretation of the data

4.2.1 Criticisms of factor analysis

To ensure that the use of factor analysis in this research is robust, it is worth exploring the criticisms that are levelled at its use. Mitchell (1994) proposes that the increased popularity of computer programs for statistical analysis has meant that researchers have been able to undertake factor analysis techniques without any real understanding of the underlying theory or the methodological issues that surround factor analysis. Mitchell (1994) refers to this as the:

> *"Unthinking use of multivariate techniques." (Mitchell, 1994, p4)*

It is this "blind use" of factor analysis that is the main reason for dissatisfaction with the technique (Mitchell, 1994; Stewart, 1981). It is important therefore to ensure throughout this analysis that these criticisms are addressed. The next section aims to demonstrate how factor analysis can be used as a model building technique.

4.2.2 Factor Analysis: Decision process

Choosing the appropriate analysis within factor analysis is complex, due to the possible combinations available to the researcher. To ensure that the rigour of factor analysis is achieved, there are a number of analytical models available (Coakes & Steed, 2001; de Vaus, 1999; Hair *et al,* 1995) .

Coakes and Steed (2001) propose a three-step analytical procedure, as follows:

> *1. Computation of the correlation matrix - To determine the appropriateness of the factor analytic model.*
>
> *2. Factor extraction - to determine the number of factors necessary to represent the data.*
>
> *3. Rotation - to make the factor structure more interpretable. Rotation may be orthogonal (the factors are uncorrelated with one another) or oblique (factors are correlated). The choice of rotation is both empirically and theoretically driven. The criteria for making the selection can be found in any good multivariate text.*
>
> *(Coakes & Steed, 2001, p155)*

A four-step approach to factor analysis is proposed by de Vaus (1999, p258):

> *1. Select variables to be factor analysed.*
>
> *2. Extract an initial set of factors.*
>
> *3. Extract a final set of factors by "rotation"*
>
> *4. Construct scales for use in further analysis.*

When these two models are compared it can be seen that there are similarities but there are also differences. The similarities are that both models identify the extraction of factors and the rotation of factors as two clearly defined stages.

The model of analysis proposed by Coakes and Steed (2001) includes a preliminary stage of analysis, which is an examination of the correlation matrix, to ensure the appropriateness of factor analysis. This initial check of the appropriateness of factor analysis is not addressed by the de Vaus (1999) model of analysis. However, de Vaus (1999) does propose that the right variables are selected for factor analysis and goes on to suggest that a scale is developed to allow further analysis.

A model of analysis that incorporates the strengths of the previous two models (Coakes & Steed, 2001; de Vaus, 1999) and aims to minimise the weaknesses, is a seven-stage model-building paradigm (Hair *et al,* 1995). This model outlines the decision making process required during factor analysis design, and also during the analysis and interpretation of results.

Therefore to ensure that the analysis is robust and appropriate, it is this seven-stage model-building paradigm that will be used (Hair *et al,* 1995). The seven stages of the model-building paradigm can be seen in Figure 4.1. Each stage will now be discussed in detail.

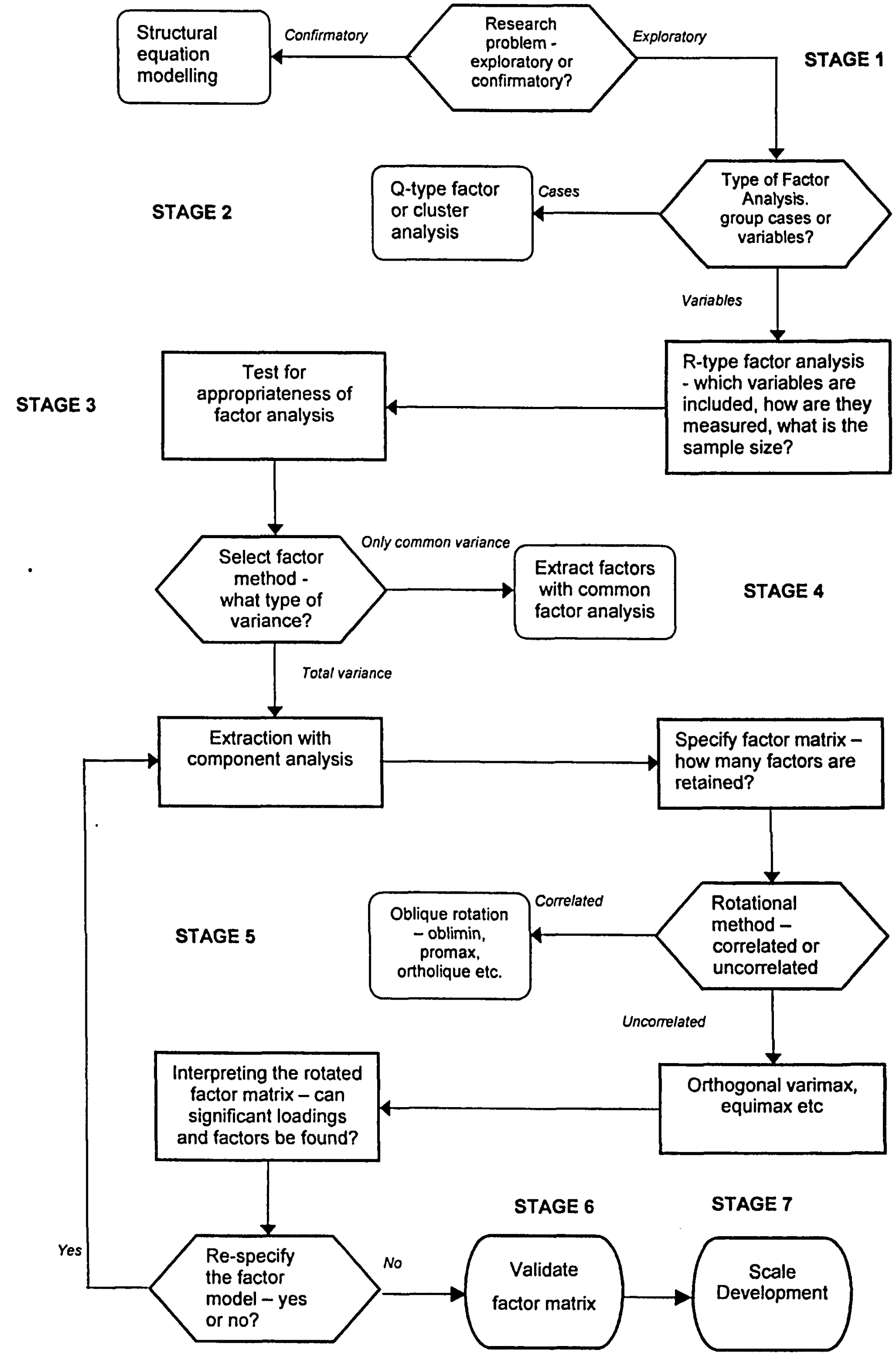

Figure 4.2 Data analysis decision making diagram (Adapted from Hair *et al*, 1995, p369)

4.3 Stage1: Objectives of factor analysis

As with any research, it essential that the researcher continually redefines the research problem until the research objectives are made explicitly clear. This research investigates the effects that various variables have on perceived productivity. In total 27 variables were presented to a sample, n = 996, for evaluation. It is a fundamental part of this research that, identification and understanding of the underlying evaluative dimensions of the data be established. It is intended that by reducing the original variables to a smaller number of dimensions (factors), a more detailed conceptual awareness of the effects that the office environment have on productivity will emerge.

4.3.1 Identifying structure through data summarization

Whilst factor analysis aims to establish relations between either respondents or variables, it fundamentally is an exploratory method of analysis, although under certain circumstances it can be used as a confirmatory method. This research uses factor analysis in both an exploratory and confirmatory way. The initial stages of the analysis are exploratory in that the aim is to try to establish underlying dimensions in the data. Once this is established, the analysis turns to a more confirmatory approach as a means of establishing the validity of the dimensions.

To ensure that the appropriate factor analysis is undertaken, consideration was given to the types of factor analysis available. The two options being R-type factor analysis and Q-type factor analysis. R-type factor analysis aims to identify correlation between variables, thus developing an underlying structure of the variables. In contrast Q-factor analysis aims to establish correlations between respondents.

> *"Q factor analysis is a method of combining or condensing large numbers of people into distinct different groups within a larger population." (Hair* et al, *1995, p95)*

The decision as to which type of factor analysis to use is based on the research objectives. This research aims to establish underlying structure of the variables, and therefore identify conceptual issues, by establishing correlations between variables. Therefore it is appropriate to use R-type factor analysis as opposed to Q-type factor analysis.

Data summarisation can be an end in itself as a way of establishing underlying conceptual dimensions. The aim of this research is to progress a stage further and to use not only the factors identified, but also the corresponding factor loadings to reduce the data. It is intended that by replacing the original data with the reduced variables subsequent analysis can be undertaken with summated scales.

4.3.2 Variable selection

The variables in the questionnaire fall into two main categories. Firstly there are the categorising variables, which allow the data to be subdivided in to various groups for subsequent analysis. Secondly there are the evaluative variables, which form the basis for the assessment of productive office environments. It is the evaluative variables that are used in the factor analysis.

There are 27 evaluative variables in total, and for ease of presentation, they were presented in three groups in the questionnaire[25]. The three groups were office facilities (Oseland, 1999; Oseland & Bartlett, 1999), environmental conditions (Leaman & Bordass, 2000) and space and you, (new behavioural elements). The three groups represented the three different conceptual areas. The allocation of variables into groupings was based on commonalties between variables. The use of factor analysis allows the initial groupings to be assessed.

> *"Even though not truly confirmatory, exploratory factor analysis is used to evaluate the proposed dimensionality." (Hair et al, 1995, p97)*

[25] The evaluation of the conceptual groupings, used in the questionnaire, will be discussed in more detail in section 4.6.2.

Having clarified the objectives of the factor analysis, consideration was given to its design. Specific issues relating to the variable type and sample size will be discussed during the next stage of the decision process.

4.4 Stage 2: Designing for factor analysis

4.4.1 Measurement issues.

It is important to classify the types of data that have been collected. The categorising data were nominal data, whilst the evaluative data were ordinal data, derived from Likert scales.

Having the measurement of the variables in the correct format is a basic requirement before factor analysis can be undertaken (de Vaus, 1999; Hair *et al,* 1995) .

Hair *et al* (1995) state that:

> *"Variables for factor analysis are generally assumed to be of metric measurement." (Hair* et al, *1995, p98)*

This requirement for the variables to be in a metric measurement format is a supported by de Vaus (1999).

> *"Factor analysis is appropriate method for scale development when you have a set of interval level, non-dichotomous variables." (de Vaus, 1999, p257)*

As previously identified the evaluative data collected were ordinal, and it would be inappropriate to undertake factor analysis with the data in this format. Therefore, for factor analysis to be undertaken there was a requirement to convert the ordinal data into a metric measure.

> *"It is generally assumed that many "ordinal variables" may be given numeric values without distorting the underlying properties." (Kim & Meuller, 1978a, p73-74)*

The conversion of the variables from ordinal to numerical values was achieved by the use of *dummy variables* (Hair *et al,* 1995). The coding for the dummy variables ranged between 1-5, as can be seen in Table 4:1.

Table 4:1 Coding of the dummy variables

Ordinal Variable	Dummy Variable
Very Negative	1
Negative	2
Neutral	3
Positive	4
Very Positive	5

The lowest number indicating the very negative end of the continuum; and the highest number the very positive end of the continuum. A neutral response was represented by the value 3. Using the *dummy variables,* with the appropriate coding, allowed the ordinal data to be converted into interval data, therefore creating the basis for factor analysis.

4.4.2 Sample size

When determining the appropriate sample required for factor analysis to be undertaken, there appeared to be a range of options.

> *"The researcher would not factor analyse a sample fewer than 50 observations, and preferably the sample size should be 100 or larger. As a general rule, the minimum is to have at least five times as many observations as there are variables to be analysed, and a more acceptable size would have a ten-to-one ratio. Some researchers even propose a minimum of 20 cases for each variable. " (Hair* et al, *1995, p98-99)*

However, Hair *et al* (1995) do not support the claim, by reference to other authors, that some researchers propose 20 cases for each variable, although some of the other criteria for sample size are supported by Coakes and Steed (2001).

> *"A minimum of five subjects per variable is required for factor analysis. A sample of 100 subjects is acceptable but sample sizes of 200+are preferable." (Coakes & Steed, 2001, p55)*

Both Hair *et al* (1995) and Coakes and Steed (2001) appear to agree that the minimum requirement for the sample size is five times the number of variables. Therefore with 27 variables the minimum sample size would be 5 x 27 = **135**. Although Hair *et al* (1995) go on to suggest that 10 times the number of variables to be a more acceptable sample size. This equates to a sample size requirement of 10 x 27 = **270**. The sample size was **996** and therefore clearly satisfies this requirement. The relationship between sample size and factor loading is important, as it aids interpretation, and will be discussed again during the analysis stage of the thesis.

4.5 Stage 3: Assumptions in Factor Analysis

This section aims to explore the underlying assumptions of factor analysis, and to develop an argument that, for the dataset gathered in this research, factor analysis is an appropriate technique of analysis.

Specific evaluative methods will be used to assess the appropriateness of factor analysis as a data analysis technique. This will be achieved by the application of visual inspection techniques and the evaluation of specific statistical values.

To confirm that factor analysis was an appropriate mode of analysis, a number of visual inspections were undertaken to establish the factorability of the data. Visual inspections undertaken included:

i) The correlation matrix,

ii) The commonalities table

ii) The anti-image correlation matrix.

4.5.1 Factorability of the correlation matrix

The correlation matrix was inspected to ensure that there were sufficient correlations to support the application of factor analysis. The visual inspection of a correlation matrix (Appendix D) revealed that a substantial number of correlations were greater than a 0.3, indicating that factor analysis was appropriate (Coakes & Steed, 2001; Hair *et al,* 1995) .

4.5.2 Commonalities table

Mitchell (1994) proposes that a visual inspection of the commonalities table is also required to support the application of factor analysis. Examination of the commonalities revealed a range of values between 0.327 and 0.816, with 89 percent of the commonalities being greater than 0.5 (Table 4:2). Since the majority of commonalities values are greater than 0.5 then this is another indication that factor analysis is an acceptable form of analysis for this data set (Mitchell, 1994).

Table 4:2 Local authority commonalities table

Communalities

	Initial	Extraction
Workarea, Desk	1.000	.639
Personal storage	1.000	.691
General storage	1.000	.634
Formal meeting areas	1.000	.709
Informal meeting areas	1.000	.783
Quiet areas	1.000	.721
Circulation space	1.000	.530
Position colleagues	1.000	.556
Position equipment	1.000	.327
Refreshment	1.000	.395
Overall office layout	1.000	.730
Heating	1.000	.548
Natural lighting	1.000	.592
Artificial lighting	1.000	.557
Ventilation	1.000	.645
Noise	1.000	.572
Cleanliness	1.000	.628
Decor	1.000	.610
Overall comfort	1.000	.733
Physical Security	1.000	.455
Social Interaction	1.000	.816
Work Interaction	1.000	.770
Creative physical environment	1.000	.606
Privacy	1.000	.633
Interruptions	1.000	.739
Crowding	1.000	.671
Overall atmosphere	1.000	.705

Extraction Method: Principal Component Analysis.

4.5.3 Anti-image correlation matrix

The visual inspection of the anti-image correlation matrix (Appendix E) consists of two parts, i.e. the evaluation of the partial correlations among variables and the evaluation of the measure of sampling adequacy for each variable.

Hair *et al* (1995) defines the anti-image correlation matrix as:

> *"Matrix of the partial correlations among variables after factor analysis representing the degree to which the factors " explain" each other in the results. The diagonal contains the measures of sampling adequacy for each variable, and the off-diagonal values are partial correlations among variables." (Hair* et al,*1995, p88)*

A visual inspection of the anti-image correlation matrix revealed that the majority of partial correlations were low, which satisfies one part of the criteria for acceptance (Hair *et al,* 1995).

The other part of the criteria for acceptance is the Measure of Sampling Adequacy (MS) value for each variable. The majority of the MSA values, for the individual variables as identified by the diagonal on the anti-image correlation matrix, were > 0.9. An acceptable level of acceptance is 0.5 (Coakes & Steed, 2001). This is further evidence to support the application of factor analysis (Hair *et al,* 1995).

The three visual inspection techniques used throughout this evaluation create evidence to support the appropriateness of factor analysis. To add weight to the claims that factor analysis is appropriate, and to test the factorability of the of the correlation matrix as a whole, further tests were undertaken (Coakes & Steed, 2001). These were the *Bartlett Test of Sphericity* (Bartlett, 1954) and the *Measure of Sampling Adequacy (MS)* (Kaiser, 1970).

4.5.4 The Bartlett test of sphericity

The Bartlett test of sphericity is a statistical test which enables the researcher to assess the probability that the correlation matrix has significant correlations among at least some of the variables (Hair *et al,* 1995; Tobias & Carlson, 1969).

> *"The Bartlett's test of sphericity should be significant (p< .05) for the factor analysis to be considered appropriate." (Pallant, 2001, p153)*

Bartlett test of sphericity is significant (p= .000), as can be seen in Table 4:3. This allows the rejection of the hypothesis that the correlation matrix has come from a population of variables that are independent (Mitchell, 1994). Once again supporting the appropriateness of factor analysis.

Table 4:3 Kaiser-Meyer-Olkin and Bartlett's tests

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.950
Bartlett's Test of Sphericity	Approx. Chi-Square	13494.462
	df	351
	Sig.	.000

4.5.5 Keiser-Meyer-Olkin measure of sampling adequacy

The final test for appropriateness used was the Keiser-Meyer-Olkin Measure of Sampling Adequacy (MS) (Kaiser, 1970). It has been argued that this is the best method currently available for assessing the appropriateness of factor analysis (Mitchell, 1994, Stewart, 1981).

The measure of sampling adequacy aims to establish the degree of inter-correlations among the variables (Hair *et al,* 1995). The measure enables the researcher to assess how well the variables belong together and therefore the appropriateness of factor analysis (Mitchell, 1994).

The results of the measurement are within a range from 0 to 1. To achieve a measurement of 1, each variable should be predicted, without error, by the other variables (Hair *et al,*1995).

The following guidelines have been presented to aid interpretation: >0.9-marvellous; >0.8-meritorious; >0.7-middling; >0.6- mediocre; >0.5-miserable and < 0.5-unacceptable (Hair *et al,*1995).

From Table 4:3 it can be seen that the dataset had a MSA of **0.95.** This value clearly puts the result in the "marvellous" category, and therefore supporting the proposal that factor analysis is an acceptable analytical tool for the data set.

Having undertaken a range of assessment methods to test the appropriateness of the data set for factor analysis, it can be concluded that there is significant evidence to support the application of factor analysis.

4.6 Stage 4: Deriving factors and assessing overall fit

Having previously assessed, and confirmed, the appropriateness of factor analysis for this research during the previous stages, this stage aims to extract the factors, i.e. conceptual dimensions, that are underpinning the evaluative variables. The extraction process consists of two elements. The first element is the determination of the extraction method; the second element is the identification of the number of factors to be extracted.

4.6.1 Factoring method

There are a wide range of methods available for factor analysis. There are seven methods available within the statistical computer package SPSS version 10. These are:

1. Principal components (PC)
2. Unweighted least squares
3. Generalised least squares
4. Maximum likelihood
5. Principal axis factoring (PAF)

6. Alpha factoring

7. Image Factoring

Of the seven different factoring methods available, the ones that are used most frequently are principal components and principal axis factoring (Coakes & Steed, 2001). There appears to be a wide range of views and opinions, within the literature, as to which is the most appropriate factor model to be used during the analysis (Coakes & Steed, 2001; Hair *et al,*1995). Coakes and Steed (2001) demonstrate the use of the principal axis factoring method, but do not justify the criteria of assessment used when determining its use.

There is a notion that during the initial stages of analysis the researcher should not be too concerned with the factoring method, but be more concerned about identifying a smaller number of factors that can explain the covariation of a larger number of variables (Kim & Meuller, 1978b). Although Kim & Mueller (1978b) explain that this is only at the initial stages of analysis, until the researcher has a clearer understanding of the methods available.

To assist in the decision making process as to which factor method to use, it would be appropriate to discuss in greater detail the difference between the two main factor methods, i.e. component analysis (or principal component analysis) and common factor analysis.

> *"Component analysis is used when the objective is to summarise most of the original information (variance) in a minimum number of factors for prediction purposes." (Hair* et al,*1995, p100)*

> *"Common factor analysis is used primarily to identify underlying factors or dimensions that reflect what the variables share in common." (Hair* et al,*1995, p100)*

The correlation matrix, for component analysis has a diagonal value of unity, i.e.1, whilst the diagonal value of the correlation matrix for common factor analysis is communality value, i.e. estimates of the shared variance (Kim & Meuller, 1978a; Hair *et al,*1995).

To be able to develop a deeper understanding of the two different methods, and to differentiate between the methods, then the concept of variance has to be discussed further.

Total variance can consist of three sub components. These being: common variance, specific variance (also known as unique), and error variance.

> *"Common variance is defined as that variance in a variable that is shared with all or the variables in the analysis. Specific variance is that variance associated with only a specific variable. Error variance is that variance due to unreliability in the data gathering process, measurement error, or random component in the measurement phenomenon."* *(Hair* et al,*1995, p101-102)*

When principal components analysis is used, the total variance accounted for in the factor matrix consists of the common variance, the specific variance and error variance. This means that all variance in the data is represented in the factor solution. A limitation of the principal component analysis is that, if the error variance is large, then that factor solution could be distorted (Hair *et al,*1995). It is therefore important to ensure that the reliability of the test instrument, i.e. questionnaire, is as high as possible.

In contrast, factors that are extracted using common factor analysis do not include the specific and error variance, but only the shared, or common, variance. Hair *et al* (1995) argue that if the researcher has little, or no knowledge, of the specific and error variance, then common factor analysis is the most appropriate factoring method. It has be argued that this is a more theoretically sound approach (Hair *et al,*1995). Although, Hair *et al* (1995), acknowledge that common factor analysis has a number of complications which have contributed to component analysis being more widely used.

Since the objective of this research is to determine the minimum number of factors needed to account for the maximum proportion of variance represented in the original set of variables, then principal component analysis is the most appropriate model. However, principal component analysis assumes that the researcher has knowledge about the error variance (i.e. the variance owing to the unreliability in the data gathering process or a random event in the measured phenomenon). Reliability tests (Cronbach's alpha tests) were undertaken and will be discussed in greater depth later in the thesis, however it is appropriate at this stage to state that the reliability of the test instrument, the questionnaire, was high, indicating that the error variance was low, supporting the application of the component analysis (Mitchell, 1994).

Having discussed the theoretical appropriateness of component analysis, Hair *et al* (1995) propose that, under certain circumstances, common factor analysis and principal component analysis can produce the same results.

> *"Although all there remains considerable debate over which factor model is the most appropriate, empirical research has demonstrated similar results in many instances. In most applications, both component analysis and factor analysis arrived at essentially identical results if the number of variables exceeds 30, or the commonalities exceed 0.6 for most of the variables. If the researcher is concerned with the assumptions of component analysis, then common factor analysis should also be applied to assess its representation of structure." (Hair et al, 1995, p103)*

Since this research was exploratory in purpose, it was determined to conduct both principal component analysis and common factor analysis.

Whilst principal component analysis produces a unique solution, there is only one method for completing a principal component analysis, with common factor analysis there are a range of options depending on the choice of the estimation technique adopted (Kim & Meuller, 1978a).

> *"Historically speaking, most of the expository treatments for factor analysis identified the common factor model by a principal axis factoring procedure, which uses their decomposition strategies of principal component analysis as applied to the adjusted correlation matrix holes diagonal elements (see off one) are replaced by corresponding estimates of commonalities." (Kim & Meuller, 1978a, p21)*

Principal axis factoring was the common factor analysis method used, as it allows a direct comparison with principal component analysis, since both methods *"apply the same eigan value equation to adjust the correlation matrix"* (Kim & Meuller, 1978a, p.21)

The results for the principal component analysis and the principal axis factoring, i.e. common factor analysis can be seen in Table 4:4. The common attributes column contains the variables that are common to both of the results. The columns labelled "principal component" and "principal axis" contains the variables that are unique to that particular analysis.

Table 4:4 Factors created using principal component and principal axis analysis

Factor	Common Attributes	Principal component	Principal axis
1	Ventilation, heating, natural lighting, artificial lighting, décor, cleanliness, overall comfort,		Overall atmosphere, Circulation space, Refreshments
2	Personal storage, work area –desk, general storage, overall office layout, position of colleagues	Circulation space, position of equipment and refreshment	
3	Interruptions, crowding, noise, privacy	Overall atmosphere	
4	Social interaction, work interaction, creative physical environment, and physical security		Position of equipment
5	Informal meeting areas, formal meeting areas, quiet areas		

The aim of this research is to identify underlying structure within the dataset. It is important, therefore, to ensure that the factors created using the statistical techniques are consistent with the conceptual issues of factor creation.

The factors created by the principal component analysis, will now be discussed, whilst at the same time comparisons will be made with the factors extracted from the principal axis factoring method.

Factor 1

The variables loading on factor 1, in Table 4:4, appear to be variables that are related to either the environmental services or the comfort of the office environment (Oseland & Bartlett, 1999; Leaman & Bordass, 2000). There is a close match between the variables loading onto factor 1 using the principal component method and the ones using principal axis factoring method. Although the first factor using principal axis factoring method, loads three extra variables. The additional variables are overall atmosphere, circulation space and refreshment.

Factor 2

The second factor created includes common attributes that tend to relate to the office layout (Duffy, 1992; Becker and Steele, 1995). In addition to the common attributes the principal component analysis creates additional variables, which are circulation space, position of equipment and refreshment.

Factor 3

The variables loading on the third factor appear to represent a common theme relating to distraction (Olson, 2002, Mawson, 2002). The only difference between the two techniques is that the principal component analysis creates an additional variable, which is overall atmosphere.

Factor 4

The fourth factor contains variables that could be generally described as interaction variables, i.e. variables that describe either the interaction between the individuals in the office environment, or interaction between the individual and the office environment. This factor appears to represent the dynamics of the office environment (Becker & Steel, 1995).

Factor 5

The variables loading onto the fifth factor using the principal component analysis are exactly the same as the variables loading using principal axis factoring. This factor contains variables that relate to different types of areas that can be incorporated into an office environment. Conceptually these variables relate to areas within the office environment (Duffy, 1992; Becker and Steele, 1995).

Having compared and contrasted the results of principal component analysis and principal axis factoring, it is clear that five factors created are conceptually comparable. This result in itself supports the claims made by Hair *et al* (1995), that under certain circumstances principal component analysis and principal axis factoring, i.e. common factor analysis can produce the same results.

Since principal component analysis offers a fuller explanation of the total variance of the data, further stages of analysis, within this thesis, will be based on the application of principal component analysis.

4.6.2 Criteria for the number of factors to extract

Having established the appropriate analysis technique, the next stage of the decision-making process is based around deciding the number of factors to be extracted. This decision does not have a simple solution, as an exact method for determining the number of factors to be extracted has not yet been developed (Hair *et al,* 1995). However, there is a range of techniques that can assist the researcher in determining the number of factors to be extracted. It should be made clear that each technique used could result in a different number of factors being extracted. It is important that the researcher explores the range of techniques so that interpretation of the most appropriate number of factors can be obtained. This iterative and adaptive process, as a means of identifying the number of factors, is in-line with the exploratory nature of this research. This is an approach supported by Hair *et al* (1995).

> *"By analogy, choosing the number of factors to be interpreted is something like focusing a microscope. Too high or too low an adjustment will obscure a structure that is obvious when the adjustment is just right. Therefore, by examining a number of different Factor structures derived from several trial solutions, the researcher can compare and contrast to arrive at the best presentation of the data." (Hair* et al, *1995, p103)*

To help develop a range of trial solutions, four techniques were used to determine the number of factors to retain. The criterion used were:

i) A priori criterion

ii) Latent root criterion

iii) Scree test criterion

iv) Percentage of variance criterion

A Priori Criterion

The a priori criterion assumes that the researcher already has a clear idea of the number of factors to be extracted. This could be because previous research has already indicated the number of factors, or alternatively the researcher is hypothesising the number of factors. In this research there is no previous evidence to suggest the number of factors, although when the questionnaire was designed the 27 variables were distributed across three categories. Therefore, as a start point to determining the number of factors, component analysis was run with the factor extraction set at three and the varimax rotation method chosen[26]. The results of the analysis can be seen in Table 4:5. The creation of three factors allows comparisons between the variables loading onto the three factors and the variable categorisation used in the questionnaire.

[26] The varimax rotation method will be discussed in greater detail in section 4.7.1.

Table 4:5 Three factors created using principal component analysis

Rotated Component Matrix[a]

	Component		
	1	2	3
Ventilation	.761	.179	.162
Natural lighting	.719	.126	.150
Artificial lighting	.712	.139	.167
Overall comfort	.666	.367	.384
Heating	.665	.143	.174
Cleanliness	.644	.283	.282
Decor	.604	.364	.235
Overall atmosphere	.525	.333	.525
Overall office layout	.494	.461	.474
Noise	.466	.409	.211
Crowding	.455	.423	.223
Informal meeting areas	.115	.799	.160
Quiet areas	.221	.771	.150
Formal meeting areas	.138	.759	.173
Privacy	.458	.520	.236
Personal storage	.278	.502	.380
General storage	.335	.499	.353
Interruptions	.423	.485	.154
Circulation space	.416	.453	.356
Social Interaction	8.887E-02	4.642E-02	.849
Work Interaction	.142	.152	.820
Position colleagues	.225	.272	.609
Physical Security	.361	.100	.514
Creative physical environment	.389	.425	.485
Workarea, Desk	.354	.356	.481
Position equipment	.175	.224	.469
Refreshment	.177	.299	.408

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

To assist in the analysis, Table 4:6 presents the three categories used in the questionnaire alongside the three factors created by a principal component analysis. The common attributes column contains the variables that are common to both the questionnaire and the component analysis results. The columns labelled "questionnaire" and "principal component" contain the variables that are unique to that particular category.

Table 4:6 Comparison of questionnaire categories with three factors created using principal component analysis

Factor	Common Attributes	Questionniare	Principal component
1	Heating, natural lighting, artificial lighting, ventilation, noise, cleanliness, décor, overall physical comfort		Overall atmosphere, overall office layout, crowding
2	Personal storage, general storage, formal meeting areas, informal meeting areas, quiet areas, circulation space	Work area, position of colleagues, position of equipment, refreshment, overall office layout	Privacy, interruptions
3	Physical security, social interaction, work interaction, creative physical environment	Privacy, interruptions, crowding, overall atmosphere	Work area, position of colleagues, position of equipment, refreshment,

The variables loading onto the first factor correlate well with the questionnaire category of "environmental conditions". The additional variables created by the component analysis are overall atmosphere, overall office layout and crowding. These variables could understandably be part of this factor, if it is accepted that this factor is more than environmental conditions and probably more about the individuals' comfort in their office environment (Leaman & Bordass, 2000).

The second factor created using principal component analysis matches some of the variables labelled "office facilities" in the questionnaire. The two notable exceptions are privacy and interruptions. These two variables add an element of interaction between the individual, other office occupants and the office environment. This factor appears to relate to a wider concept of office layout (Duffy, 1992). It should be noted that a number of variables in the questionnaire did not load onto this factor, but loaded onto the third factor.

The final factor is in general agreement with the third category of the questionnaire. This category aimed at understanding the individual and their working environment (Becker & Steele, 1995). The exceptions, such as work area, position of colleagues, position of equipment and refreshment are all variables from the questionnaire category office facilities, although it can be understood that each of these has an individual dimension.

There appears to be some correlation between the categories used in the questionnaire and the factors created using principal component analysis. This could be perceived as being confirmatory in nature. However the purpose of this research is more exploratory which requires that the researcher investigate a range of techniques before coming to a conclusion. The next technique to be used will be the Latent root criterion.

Latent root criterion

Of all techniques used to determine the number of factors to extract, the Latent root criterion is probably the most common (Hair *et al,* 1995). The Latent root, or as it is more commonly referred to as the eigan value, measures the variance of all the variables, which are loaded onto a particular factor. The principle behind the Latent root criterion is that each component should explain at least the variance of one variable. To achieve this, the eigan value be must be at least 1 to be considered significant (Hair *et al,* 1995; Kaiser, 1960).

Table 4:7 shows how the total variance is explained using eigenvalues and cut-off point set at 1.

Table 4:7 Total variance explained with eigan value set at 1.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.702	43.341	43.341	11.702	43.341	43.341	4.498	16.658	16.658
2	1.554	5.757	49.098	1.554	5.757	49.098	3.522	13.045	29.704
3	1.432	5.302	54.400	1.432	5.302	54.400	3.169	11.736	41.440
4	1.239	4.588	58.989	1.239	4.588	58.989	2.922	10.821	52.260
5	1.066	3.950	62.939	1.066	3.950	62.939	2.883	10.678	62.939
6	.987	3.655	66.593						
7	.837	3.101	69.694						
8	.719	2.664	72.359						
9	.673	2.494	74.852						
10	.637	2.358	77.210						
11	.580	2.147	79.358						
12	.558	2.068	81.426						
13	.542	2.009	83.434						
14	.470	1.740	85.174						
15	.420	1.554	86.728						
16	.418	1.547	88.275						
17	.398	1.475	89.750						
18	.362	1.342	91.092						
19	.331	1.227	92.319						
20	.316	1.172	93.491						
21	.297	1.098	94.589						
22	.281	1.042	95.631						
23	.265	.981	96.612						
24	.253	.937	97.549						
25	.233	.864	98.413						
26	.229	.847	99.260						
27	.200	.740	100.000						

Extraction Method: Principal Component Analysis.

Table 4:7 displays the total variance explained at three stages, i.e. initial eigan values, the extraction sums of the squared loadings and the rotation sums of squared loadings. It is the initial stage that is important at this stage of the investigation. The initial stage represents the principal components and their associated eigan values, the percentage of variance explained and the cumulative percentages (Coakes & Steed, 2001).[27]

Table 4:7,column 2, illustrates the eigan value for each principal component, with the first component having a value of 11.702. All the eigan values, in column 2, represent the total variance. The summation of this column equates to 27, which is the total number of variables used in this analysis.

From column 5, in Table 4:7, it can be seen that with an eigan value of 11.702 the first component to be loaded represents 43.34 per cent of the total variance. The

[27] The results obtained under the "Initial Eigan values" explain the variance before the factors are rotated. The results under "Rotated Sums of Squares Loadings" explain the variance after factor rotation.

subsequent eigan values, that have a value greater than one, range between 1.066 and 1.554, these represent the next four factors. Therefore it can be seen that the number of factors extracted using the latent root criterion technique was five.

Table 4:8 shows the rotated component matrix from a principle component analysis with the eigan value set at 1.

Table 4:8 Rotated component matrix with an eigan value of 1.

Rotated Component Matrix	Component				
	1	2	3	4	5
Natural lighting	0.727				
Ventilation	0.713				
Heating	0.680				
Artificial lighting	0.672				
Cleanliness	0.658				
Overall comfort	0.619				
Decor	0.618				
Personal storage		0.744			
Workarea, Desk		0.676			
General storage		0.67			
Overall office layout		0.586			
Position colleagues		0.554			
Circulation space		0.462			
Position equipment		0.409			
Refreshment		0.397			
Interruptions			0.8		
Crowding			0.715		
Noise			0.639		
Privacy			0.582		
Overall atmosphere			0.478		
Social Interaction				0.875	
Work Interaction				0.807	
Physical Security				0.514	
Creative physical environment				0.447	
Informal meeting areas					0.826
Formal meeting areas					0.768
Quiet areas					0.742

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations

Although labelling of the factors will be developed later in the thesis, when the exact number of factors to be extracted will be known, it is clear from Table 4:8 that conceptual themes have been created. Factor 1 contains variables that could generally be described as environmental services (Leaman & Bordass, 2000).

Factor 2 variables appear to have a commonality around the concept of office layout (Duffy, 1992). Factor 3 variables appear to describe office protocols or distractions (Mawson, 2002; Olson, 2002). Factor 4 appears conceptually to be describing interaction between the individual and their office environment (Becker & Steele, 1995). Factor 5 clearly relates to the concept of different types of space within an office (Duffy, 1998).

To determine if the five factors adequately explained the underlying structure of the data, Table 4:7 was examined. It was observed that the eigan value for the sixth factor was 0.987, which is very close to the cut-off point of 1. With a strict adherence to the cut-off point being set at one, the possibility exists that another factor has possibly been lost. Therefore, as part of the exploratory purpose of this research, the analysis was re-run, but with a cut-off point set at 0.95 which allowed the inclusion of the sixth factor. Table 4:9 shows how the total variance is explained using eigan values and cut-off point set at 0.95.

Table 4:9 Total variance explained with an eigan value of 0.95

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.702	43.341	43.341	11.702	43.341	43.341	4.487	16.618	16.618
2	1.554	5.757	49.098	1.554	5.757	49.098	3.206	11.874	28.492
3	1.432	5.302	54.400	1.432	5.302	54.400	2.852	10.562	39.054
4	1.239	4.588	58.989	1.239	4.588	58.989	2.800	10.369	49.423
5	1.066	3.950	62.939	1.066	3.950	62.939	2.756	10.209	59.632
6	.987	3.655	66.593	.987	3.655	66.593	1.880	6.961	66.593
7	.837	3.101	69.694						
8	.719	2.664	72.359						
9	.673	2.494	74.852						
10	.637	2.358	77.210						
11	.580	2.147	79.358						
12	.558	2.068	81.426						
13	.542	2.009	83.434						
14	.470	1.740	85.174						
15	.420	1.554	86.728						
16	.418	1.547	88.275						
17	.398	1.475	89.750						
18	.362	1.342	91.092						
19	.331	1.227	92.319						
20	.316	1.172	93.491						
21	.297	1.098	94.589						
22	.281	1.042	95.631						
23	.265	.981	96.612						
24	.253	.937	97.549						
25	.233	.864	98.413						
26	.229	.847	99.260						
27	.200	.740	100.000						

Extraction Method: Principal Component Analysis.

Comparing and contrasting the results created in Table 4:7, the total variance explained using and eigan value of 1, with the results created using an eigan value of 0.95, Table 4:9, it can be seen that the three columns under the "Initial Eigan values" are exactly the same. The only difference between the two tables is that sixth component is maintained in the fifth to tenth columns in Table 4:9. This means that by including the sixth component 66.6% of the variance is explained, as opposed to 62.939% being explained with 5 factors. To determine if the extra factor adds conceptually to the understanding of the data, the rotated factor matrix needs to be examined (Table 4:10).

Table 4:10 Rotated component matrix with an eigan value set at 0.95

Rotated Component Matrix

	Component					
	1	2	3	4	5	6
Natural lighting	0.73					
Ventilation	0.72					
Heating	0.68					
Artificial lighting	0.67					
Cleanliness	0.65					
Overall comfort	0.62					
Decor	0.61					
Interruptions		0.81				
Crowding		0.73				
Noise		0.66				
Privacy		0.59				
Overall atmosphere		0.47				
Personal storage			0.78			
General storage			0.71			
Workarea, Desk			0.68			
Overall office layout			0.49			
Position colleagues			0.46			
Circulation space			0.36			
Informal meeting areas				0.83		
Formal meeting areas				0.78		
Quiet areas				0.74		
Social Interaction					0.87	
Work Interaction					0.82	
Physical Security					0.53	
Creative physical environment					0.44	
Position equipment						0.77
Refreshment						0.72

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations

Comparing and contrasting Table 4:8 and Table 4:10 it can be seen that the first five factors are comparable, although acknowledging that the sequence is different.[28] The variables loading onto the extra factor were previously loaded onto factor 2. Table 4:8 factor 2 variables have previously been identified as relating to the office layout. The question then becomes does the new factor created using an eigan value of 0.95 actually add to the conceptual understanding.

The new factor could be perceived as being a sub-element of the office layout factor, and therefore, as an additional factor, does not add to the structural understanding of the data. However, there does appear to be an extra dimension which goes beyond office layout and that is that the two variables could conceptually be linked together if perceived as informal meeting points.

This tension between the minimum number of factors and maximum explanation of data is not uncommon (Hair *et al,* 1995). It must be acknowledged that the final decision will be based on the researcher's interpretation of the factors and the objectives of the research.

> *"It is up to the researcher to determine the number of factors that he/she considers best describes the underlying relationship among variables. This involves balancing two conflicting needs: the need to find a simple solution with as few factors as possible; and the need to explain as much of the variance in the original data set up as possible." (Pallant, 2001, p153)*

There is conceptual justification for maintaining the extra factor and therefore the conclusion of using the latent root criterion would be that there are six factors that conceptually underpin the data structure. It is worth continuing the application of the remaining criteria, i.e. the Scree test and percentage variance, as they could act as confirmatory techniques.

[28] Caused by the varimax rotational method which will be discussed in section 4.7.1.

Scree plot

The three different types of variance have previously been discussed in this thesis i.e. common variance, unique variance and error variance. It is the common variance that it is of importance when trying to determine underlying structure of the dataset. The unique and error variance can be considered as possible contaminants and therefore could effect the factors created. It is therefore important to establish the point where the unique and the error variance have a disproportionate effect on the total variance.

> *"Although all factors contain at least some unique variance, the proportion of unique variance is substantially higher in later factors than in earlier factors." (Hair* et al, *1995, p104)*

Hair *et al* (1995) provide the following definition of the Scree test, and reference the original source as Cattell (1966).

> *"The Scree test is used to identify the optimum number of factors that can be extracted before the amount of unique variance begins to dominate the common variance structure." (Hair* et al, *1995, p104)*

The Scree plot is a graphical representation of the relationship between that Latent root, eigan value, and the number of factors in order of extraction. The objective is to identify a point on the Scree plot that incorporates the maximum common variance before the unique variance start to contaminate the results.

> *"The point at which the curve begins to straighten out is considered to indicate the maximum number of factors to extract." (Hair* et al, *1995, p104)*

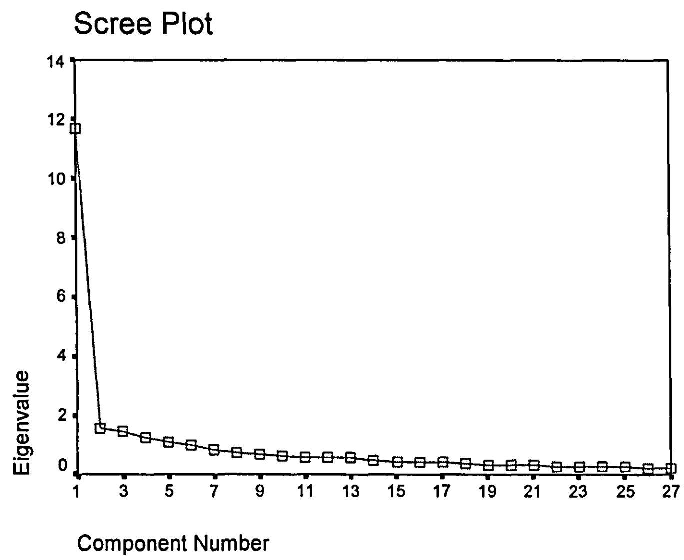

Figure 4.3 Scree plot

This is a graphical means of evaluation and therefore incorporates a certain amount of subjectivity. Examination of Figure 4.3 indicates, using the previously defined criteria, that the point at which the curve begins to straighten is around the eighth factor. There is clearly a difference between the five factors identified using the Latent root criterion, and the eight factors identified using the Scree test criterion. The difference between the factors extracted using the Latent root criterion and the Scree test criterion are not uncommon.

> *"As a general rule, the Scree test results in at least one and sometimes two or three more factors being considered for inclusion than does the Latent root criterion (Cartel, 1966)." (Hair* et al, *1995, p104)*

Therefore it is appropriate to explore the dataset, to establish if the extra factors created, using the Scree criterion, reveal any further conceptual dimensions.

Table 4:11 Total variance explained using eight factors

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.702	43.341	43.341	11.702	43.341	43.341	3.111	11.521	11.521
2	1.554	5.757	49.098	1.554	5.757	49.098	3.082	11.416	22.936
3	1.432	5.302	54.400	1.432	5.302	54.400	2.944	10.903	33.839
4	1.239	4.588	58.989	1.239	4.588	58.989	2.689	9.957	43.797
5	1.066	3.950	62.939	1.066	3.950	62.939	2.679	9.921	53.718
6	.987	3.655	66.593	.987	3.655	66.593	2.488	9.214	62.931
7	.837	3.101	69.694	.837	3.101	69.694	1.726	6.393	69.325
8	.719	2.664	72.359	.719	2.664	72.359	.819	3.034	72.359
9	.673	2.494	74.852						
10	.637	2.358	77.210						
11	.580	2.147	79.358						
12	.558	2.068	81.426						
13	.542	2.009	83.434						
14	.470	1.740	85.174						
15	.420	1.554	86.728						
16	.418	1.547	88.275						
17	.398	1.475	89.750						
18	.362	1.342	91.092						
19	.331	1.227	92.319						
20	.316	1.172	93.491						
21	.297	1.098	94.589						
22	.281	1.042	95.631						
23	.265	.981	96.612						
24	.253	.937	97.549						
25	.233	.864	98.413						
26	.229	.847	99.260						
27	.200	.740	100.000						

Extraction Method: Principal Component Analysis.

Evaluation of Table 4:11 establishes that the inclusion of the extra factors means that 72.359% of the variance is explained as opposed to 66.593% explanation of variance for six factors. The loading of variables onto the rotated factors can be seen in Table 4:12.

Table 4:12 Eight factors created with factor extraction set at 8

Rotated Component Matrix	Component							
	1	2	3	4	5	6	7	8
Interruptions	0.821							
Crowding	0.739							
Noise	0.66							
Privacy	0.55							
Ventilation		0.763						
Natural lighting		0.736						
Heating		0.697						
Artificial lighting		0.653						
Personal storage			0.79					
General storage			0.706					
Workarea, Desk			0.688					
Overall office layout			0.508					
Position colleagues			0.452					
Circulation space			0.372					
Informal meeting areas				0.836				
Formal meeting areas				0.778				
Quiet areas				0.735				
Social Interaction					0.863			
Work Interaction					0.825			
Overall atmosphere					0.454			
Creative physical environment					0.449			
Decor						0.807		
Cleanliness						0.753		
Overall comfort						0.534		
Position equipment							0.792	
Refreshment							0.711	
Physical Security								0.62

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations

Comparing and contrasting Table 4:10 and Table 4:12 it can be seen that the six factors created in Table 4:10 are reproduced in Table 4:12, although the order of loading has been transposed. The new factors created in Table 4:12 are the sixth and the eighth factor. The variables in the sixth factor could be conceptually linked if identified as "soft" elements associated with environmental comfort. The term "environmental comfort" appears to be separating into the "hard" variables, as in factor two, and the "soft" variables as in factor six. The eighth factor only contains one variable, i.e. physical security, and therefore indicates that unique variance is dominating any common variance. The indication therefore is that the factoring should be stopped before the eighth factor. The results of the eight factors indicates that seven factors can be explained conceptually, but to ensure that this is the case, the factoring procedure was run again with the factor extraction set at 7. The results of the total variance explained, for seven factors, can be seen in Table 4:13.

Table 4:13 Total variance explained using 7 factors

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.702	43.341	43.341	11.702	43.341	43.341	3.230	11.962	11.962
2	1.554	5.757	49.098	1.554	5.757	49.098	3.111	11.522	23.484
3	1.432	5.302	54.400	1.432	5.302	54.400	2.948	10.917	34.401
4	1.239	4.588	58.989	1.239	4.588	58.989	2.754	10.201	44.602
5	1.066	3.950	62.939	1.066	3.950	62.939	2.635	9.759	54.361
6	.987	3.655	66.593	.987	3.655	66.593	2.382	8.823	63.184
7	.837	3.101	69.694	.837	3.101	69.694	1.758	6.510	69.694
8	.719	2.664	72.359						
9	.673	2.494	74.852						
10	.637	2.358	77.210						
11	.580	2.147	79.358						
12	.558	2.068	81.426						
13	.542	2.009	83.434						
14	.470	1.740	85.174						
15	.420	1.554	86.728						
16	.418	1.547	88.275						
17	.398	1.475	89.750						
18	.362	1.342	91.092						
19	.331	1.227	92.319						
20	.316	1.172	93.491						
21	.297	1.098	94.589						
22	.281	1.042	95.631						
23	.265	.981	96.612						
24	.253	.937	97.549						
25	.233	.864	98.413						
26	.229	.847	99.260						
27	.200	.740	100.000						

Extraction Method: Principal Component Analysis.

Table 4:13 illustrates the total variance explained with the factor extraction set at 7. The inclusion of the extra factor means that 69.7% of the variance is explained as opposed to 66.593% explanation of variance for six factors. The loading of variables onto the rotated factors can be seen in Table 4:14.

Table 4:14 Rotated component matrix with factor extraction set at 7

Rotated Component Matrix	Component						
	1	2	3	4	5	6	7
Interruptions	0.811						
Crowding	0.726						
Noise	0.663						
Privacy	0.589						
Overall atmosphere	0.472						
Ventilation		0.755					
Heating		0.733					
Natural lighting		0.701					
Artificial lighting		0.664					
Personal storage			0.79				
General storage			0.706				
Workarea, Desk			0.689				
Overall office layout			0.508				
Position colleagues			0.454				
Circulation space			0.372				
Social Interaction				0.874			
Work Interaction				0.825			
Physical Security				0.529			
Creative physical				0.439	0.308		
Informal meeting areas					0.834		
Formal meeting areas					0.778		
Quiet areas					0.727		
Decor						0.802	
Cleanliness						0.751	
Overall comfort						0.521	
Position equipment							0.784
Refreshment							0.72

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations

Comparing and contrasting the results in the six factor analysis (Table 4:10) with the results of the seven factor analysis (Table 4:14) it can be seen that the extra factor that has been created is factor six. As discussed previously the variables loading onto this factor could be described conceptually as the environmental comfort "soft" variables.

The result of the Scree test indicates that conceptually an extra factor could be included to explain the underlying structure of the dataset. By extending the factoring procedure to eight factors no further understanding of the dataset was obtained. The last criterion to be discussed is the percentage variance criterion.

Percentage of variance criterion

The last criterion uses the percentage of variance explained as the basis for determining the number of factors to be extracted. The percentage value identified as the stop point for the factoring will be dependent on the type of research undertaken. Hair *et al* (1995) differentiates between natural science research and social science research and the differing criteria required.

> *"However, in the natural sciences the factoring procedure usually should not be stopped until the extracted factors account for at least 95 per cent of the variance or until the last factor accounts for only a small proportion (say less than five per cent). In contrast, the social sciences, where information is often less precise, it is not uncommon to consider a solution that accounts for 60 percent of the total variance (and in some instances even less) as satisfactory." (Hair* et al, *1995, p104)*

Therefore using the social science criteria of 60% of the total variance being an acceptable solution, it can be seen that the seven factor solution, with 69.694% of the total variance explained, clearly satisfies the criteria for an acceptable solution.

Summary of factor selection criteria

This section has used a number of different criteria to determine the underlying structure of the dataset. This has required the application of criteria and part interpretation being undertaken simultaneously. This process has been iterative and demonstrates that no one criterion alone can reveal the number of factors to be extracted.

The objective has been to identify the correct number of factors that explain the data, as too many factors can complicate interpretation and too few factors can omit factors that could add conceptual meaning. This process has resulted in seven factors being extracted. To aid further understanding, the next section will develop an interpretation of the seven factors extracted.

4.7 Stage 5: Interpreting the factors

The objective of identifying the number of factors to be extracted can be achieved through the interrogation of the unrotated factor matrix. The correlations created in the unrotated factor matrix can been interpreted as the best linear combination of variables (Hair *et al,* 1995).

> *"- best in the sense that the particular combination of original variables accounts for more of the variance in the data as a whole than any other linear combination of variables." (Hair* et al, *1995, p106)*

The creation of an unrotated factor matrix may satisfy the mathematical requirements of factor analysis and the objective of data reduction, but can lead to difficulty in interpretation due to the lack of distribution of the variables across a range of components. Since the unrotated factor matrix can produce a large number of factor loadings onto a single component.

> *"Factor loadings are the correlation of each variable and the factor." (Hair* et al, *1995, p106)*

The results of the unrotated component matrix can be seen in Table 4:15. Examination of Table 4:15 clearly demonstrate the problems of interpretation when the majority of the variables load onto the first component.

Table 4:15 Unrotated component matrix

Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
Overall comfort	.832	-.118	-.138	7.647E-02	-3.18E-02	-4.45E-02	-.187
Overall office layout	.824	4.498E-02	3.109E-03	-9.51E-02	-.202	8.721E-02	-.114
Overall atmosphere	.799	8.107E-02	-.132	-.148	.145	-3.79E-02	-3.88E-02
Creative physical environment	.743	.119	2.337E-02	2.155E-02	.197	-5.10E-02	-.130
Cleanliness	.717	-.178	-.169	.228	4.547E-02	.107	-.408
Decor	.712	-.202	-6.93E-02	.235	4.166E-02	8.943E-02	-.486
Privacy	.708	-.131	.132	-.168	.262	4.845E-02	-6.17E-03
Circulation space	.708	-3.28E-03	6.655E-02	2.887E-02	-.154	.123	-5.98E-02
General storage	.681	3.682E-02	.146	-6.75E-02	-.379	-.264	3.525E-02
Workarea, Desk	.680	.143	-1.42E-02	-.191	-.346	-.164	-.106
Ventilation	.669	-.333	-.282	5.511E-02	6.329E-02	-.151	.276
Personal storage	.661	9.113E-02	.171	-.142	-.443	-.276	-4.21E-02
Quiet areas	.653	-8.77E-02	.481	.189	.143	5.872E-03	5.958E-02
Crowding	.644	-.130	5.737E-02	-.479	7.803E-02	9.999E-02	-2.77E-02
Noise	.637	-.145	4.398E-02	-.324	.197	.138	7.693E-02
Interruptions	.622	-.173	.143	-.500	.227	.103	6.921E-02
Position colleagues	.619	.330	-5.10E-02	-.168	-.180	6.205E-02	.121
Artificial lighting	.618	-.296	-.291	5.823E-02	-4.00E-03	-1.50E-02	.193
Work Interaction	.611	.561	-.163	1.958E-02	.233	-.172	6.004E-02
Informal meeting areas	.608	-2.14E-02	.555	.291	.145	-7.37E-02	.146
Formal meeting areas	.606	-1.97E-02	.507	.283	6.876E-02	-.142	9.889E-02
Natural lighting	.606	-.313	-.301	.189	-2.47E-02	-7.39E-03	.183
Heating	.594	-.264	-.266	.194	-.131	-8.91E-02	.309
Physical Security	.558	.193	-.236	.168	.148	-.148	7.881E-03
Refreshment	.497	.194	4.834E-02	.268	-.192	.489	.128
Social Interaction	.534	.627	-.230	9.235E-02	.276	-.116	3.875E-02
Position equipment	.487	.252	-2.83E-02	4.811E-02	-.153	.599	.162

Extraction Method: Principal Component Analysis.

a. 7 components extracted.

As can be demonstrated in Table 4:16 the first component explains 43.3% of the variance, and the subsequent components explain the remaining 26.4% of the variance that can be explained with this solution.

From the results illustrated in Table 4:15 it is not possible to create any meaningful interpretation. Therefore there was a requirement to rotate the components, with the objective of trying to simplify the component structure and aid in theoretical interpretation.

Table 4:16 Total variance explained for unrotated components

Total Varience Explained						
	Initial Eiganvalues			Extraction Sums of Squared Loadings		
Component	Total	% Of Variance	Cumulative %	Total	% Of Variance	Cumulative %
1	11.7	43.3	43.3	11.7	43.3	43.3
2	1.6	5.8	49.1	1.6	5.8	49.1
3	1.4	5.3	54.4	1.4	5.3	54.4
4	1.2	4.6	59	1.2	4.6	59
5	1.1	3.9	62.9	1.1	3.9	62.9
6	1	3.7	66.6	1	3.7	66.6
7	0.8	3.1	69.7	0.8	3.1	69.7

4.7.1 Rotation of factors

To assist in the interpretation of the factors, the factor vectors are rotated upon their axis to a position that allows a more meaningful interpretation of the variables and the factors created. This process addresses the limitation of the unrotated factor matrix, i.e. the first factor explaining the majority of the variance, by allowing for a redistribution of variance across the other factors created.

When considering rotating factors, the researcher has initially one of two options. The first option is to rotate the axis, whilst maintaining a 90-degree angle between the factors. This approach is termed an orthogonal rotation and assumes that the factors created are uncorrelated. The second option, oblique rotation, does not constrain the factors during rotation and therefore allows correlation between factors to exist.

The determination as to the choice of orthogonal or oblique rotation is very much dependent on the aims of the research question, as there are no specific rules to guide the researcher in this matter (Hair *et al,* 1995). If the researcher's objective was to reduce the data from a larger set of variables to a smaller set of variables, then the orthogonal solution would be most appropriate. However, if the research objective is to identify underlying theoretical constructs, then the oblique rotation method is more appropriate (Hair *et al,* 1995).

A practical approach to determining the appropriate rotational method would be to take the view that it would be unlikely that the factors created are not correlated in some way, which supports the oblique rotation method as opposed to the orthogonal method. It appears that from a theoretical and a practical viewpoint the oblique rotation method appears to be the most appropriate solution. However, since the aim of this research is to explore all options, it was decided to conduct both orthogonal and oblique rotation methods. This is an approach that is supported by other researchers.

> *"The careful researcher should almost invariably perform both orthogonal and oblique rotation, particularly in exploratory work." (Stewart, 1981, p61)*

Orthogonal rotation methods

The output created, from the orthogonal rotation method, is either a factor or a component matrix. To aid in the interpretation of the factor matrix it is important to identify how the factor matrix is produced, and an understanding of the components that make up the factor matrix.

> *"In practice, the object of all methods of rotation is to simplify the rows and columns of the factor matrix to facilitate interpretation. In a factor matrix, columns represent factors, with each row corresponding to a variables loading across the factors. By simplifying the rows, we mean making as many values in each row as close to zero as possible (i.e., maximising a variables loading on a single factor). By simplifying the columns, we mean making as many values in each column as close to zero as possible (i.e., making it the number of high loadings as few as possible)." (Hair* et al, *1995, p109)*

There are three major orthogonal methods that can be used. They are QUARTIMAX, VARIMAX and EQUIMAX.

The QUARTIMAX rotational method works on the principle of rotating the initial solution so that the variables load high on one factor, and low on subsequent factors. This tends to create a situation where one factor dominates to extent of the subsequent factors. It is for this reason that this approach is inappropriate since it does not aid in creating a simpler structure for interpretation.

The VARIMAX rotational method aims to simplify the initial solution by concentrating on the columns of the factor matrix. The objective is to try to establish ones and zeros in the column. Therefore clearly establishing that a variable is loaded onto a factor or has no correlation with the factor. This approach allows clear creation of separate factors. It should be noted that the VARIMAX rotational method has been proved to be a successful orthogonal rotational method (Hair *et al,* 1995).

The last orthogonal rotational method is the EQUIMAX method. This aims to combine the approaches of both the QUARTIMAX and the VARIMAX methods. The EQUIMAX method does not appear to be widely accepted and therefore will not be considered in this research (Hair *et al,* 1995).

Having reviewed the three orthogonal rotational methods available it was decided that the VARIMAX method would be used.

Table 4:17 shows the results of the rotated component matrix generated by using the VARIMAX orthogonal rotational method. By comparing the rotated component matrix results (Table 4:17) with unrotated component matrix (Table 4:15) it can be seen that the factor loadings are no longer distributed solely across the first component, but are more evenly distributed across the seven components.

Table 4:17 VARIMAX rotated component matrix

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
Interruptions	.811	.155	.167	8.158E-02	.174	6.833E-02	6.136E-02
Crowding	.726	.153	.289	8.608E-02	7.409E-02	.156	.102
Noise	.663	.242	.127	.133	.167	.132	.142
Privacy	.589	.230	.122	.200	.337	.246	8.000E-02
Overall atmosphere	.472	.303	.280	.445	.141	.287	.123
Ventilation	.287	.755	.151	.167	.150	.135	1.164E-03
Heating	7.855E-02	.733	.216	.104	.145	9.965E-02	.140
Natural lighting	.148	.701	.112	.101	.113	.241	.138
Artificial lighting	.254	.664	.142	.114	7.513E-02	.194	.114
Personal storage	.173	.154	.790	.128	.236	.120	6.331E-02
General storage	.162	.253	.706	.136	.285	.108	7.388E-02
Workarea, Desk	.241	.163	.689	.235	6.914E-02	.205	.126
Overall office layout	.363	.240	.508	.213	.174	.357	.316
Position colleagues	.269	.135	.454	.383	5.749E-02	9.145E-03	.357
Circulation space	.265	.234	.372	.140	.253	.315	.320
Social Interaction	8.107E-02	6.995E-02	.111	.874	8.734E-02	8.783E-02	.167
Work Interaction	.164	.104	.210	.825	.143	7.047E-02	.127
Physical Security	7.148E-02	.317	.135	.529	.127	.230	6.394E-02
Creative physical environment	.346	.181	.214	.439	.308	.360	.103
Informal meeting areas	.164	.134	.150	.139	.834	.104	.130
Formal meeting areas	.119	.146	.232	.138	.778	.133	8.390E-02
Quiet areas	.280	.145	.156	9.718E-02	.727	.200	.153
Decor	.193	.246	.177	.127	.224	.802	.122
Cleanliness	.190	.319	.154	.177	.156	.751	.159
Overall comfort	.289	.416	.349	.256	.196	.521	.125
Position equipment	.195	.100	.107	.166	6.109E-02	8.174E-02	.784
Refreshment	1.812E-02	.153	.126	.133	.224	.161	.720

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Comparison of the total variance results for the unrotated component solution (Table 4:16) and the total variance explained results of the rotated component solution (Table 4:18) shows a redistribution of factor loadings which helps to simplify the underlying structure of the variables and also aids in the interpretation.

Table 4:18 Total variance explained for VARIMAX rotated components

Total Varience Explained						
	Initial Eiganvalues			Extraction Sums of Squared Loadings		
Component	Total	% Of Variance	Cumulative %	Total	% Of Variance	Cumulative %
1	11.7	43.3	43.3	3.2	12	12
2	1.6	5.8	49.1	3.1	11.5	23.5
3	1.4	5.3	54.4	2.9	10.9	34.4
4	1.2	4.6	59	2.8	10.2	44.6
5	1.1	3.9	62.9	2.6	9.8	54.4
6	1	3.7	66.6	2.4	8.8	63.2
7	0.8	3.1	69.7	1.8	6.5	69.7

Having identified a rotated component matrix using the Varimax orthogonal method, the next stage of the analysis is to create an oblique rotational solution so that both results can be compared and contrasted.

Oblique rotation method

While orthogonal rotational methods offer a number of options, the oblique rotation method has only a few. Since the statistical analysis package used was SPSS, the rotational method applied was Oblimin.

There are two types of matrix created using the Oblimin rotational method: pattern matrix and structure matrix. It is the pattern matrix that is of interest, as it creates unique correlations between the variables and the components, unlike the structure matrix where this is not the case (Hair *et al,* 1995).

Table 4:19 illustrates the pattern matrix for the Oblimin rotation method. Inspection of the pattern matrix clearly demonstrates the distribution or factor loadings across the seven components. Inspection of column five in Table 4:20, the total variance explained for Oblimin rotated components, reiterates the fact that the variables are redistributed across the components.

In contrast to the Varimax rotated component matrix, Table 4:17, some of the variables in Table 4:19 have negative factor loadings, indicating that the variable has a negative correlation with that component. Since oblique rotation allows correlation between components, this means that components could be negatively correlated. Components 4, 5 and 7 in Table 4:19, appear to indicate a negative correlations with the remaining components.

Comparing the results of the Varimax rotated component matrix (Table 4:17) and the results created by the Oblimin rotational method (Table 4:19) it can be seen that the same variables load on to all the same components in both instances. The only noticeable difference between the two results is that the sequence of component loadings is different. However since the aim of the research is to identify deep underlying dimensions of the variables, it can be concluded that both the oblique rotational method and the Varimax rotational method produce the same conceptual dimensions.

Table 4:19 OBLIMIN rotated components

Pattern Matrix[a]

	Component						
	1	2	3	4	5	6	7
Heating	.798	-1.53E-02	4.320E-02	9.693E-02	-.102	6.720E-02	6.473E-02
Ventilation	.798	6.454E-02	3.842E-02	-.150	6.803E-03	-.102	3.380E-02
Natural lighting	.723	-1.84E-02	-3.48E-03	1.174E-02	3.546E-02	6.414E-02	-.123
Artificial lighting	.679	-1.52E-03	-4.94E-02	-.125	2.283E-03	3.657E-02	-6.52E-02
Social Interaction	-5.24E-02	.935	2.920E-03	4.250E-02	3.877E-02	6.598E-02	1.334E-02
Work Interaction	-2.59E-02	.860	5.156E-02	-3.73E-02	-6.95E-02	1.124E-02	5.377E-02
Physical Security	.234	.515	3.112E-02	8.092E-02	-3.36E-03	-3.99E-02	-.152
Creative physical environment	-2.18E-02	.366	.197	-.213	-4.92E-02	-1.63E-02	-.297
Informal meeting areas	1.001E-02	4.043E-02	.875	-2.07E-02	-1.09E-03	4.565E-02	3.579E-02
Formal meeting areas	1.940E-02	3.664E-02	.803	4.143E-02	-.115	-8.62E-03	-6.52E-03
Quiet areas	-9.32E-03	-2.32E-02	.729	-.153	2.864E-03	7.001E-02	-8.63E-02
Interruptions	2.721E-02	-2.44E-02	7.636E-02	-.854	-1.26E-02	-1.11E-02	5.313E-02
Crowding	-3.96E-04	-3.87E-02	-6.17E-02	-.732	-.172	2.884E-02	-6.61E-02
Noise	.128	2.624E-02	6.105E-02	-.658	4.284E-02	7.364E-02	-1.62E-02
Privacy	7.219E-02	9.716E-02	.247	-.537	6.464E-02	-1.67E-02	-.148
Overall atmosphere	.137	.358	-1.33E-02	-.358	-.116	3.375E-03	-.185
Personal storage	7.551E-03	-2.33E-02	.113	4.051E-03	-.841	-3.99E-02	-1.73E-02
General storage	.137	-1.33E-02	.174	2.209E-02	-.722	-3.03E-02	1.787E-02
Workarea, Desk	-1.72E-03	.101	-9.32E-02	-8.31E-02	-.699	2.673E-02	-.128
Overall office layout	3.504E-02	4.012E-02	-1.13E-03	-.198	-.413	.227	-.282
Position colleagues	2.272E-02	.291	-7.19E-02	-.157	-.387	.300	.129
Circulation space	6.699E-02	-1.84E-02	.125	-.110	-.269	.253	-.243
Position equipment	4.361E-03	3.610E-02	-4.26E-02	-.110	3.859E-02	.823	1.759E-02
Refreshment	5.683E-02	-4.87E-03	.146	.128	8.042E-03	.742	-7.54E-02
Decor	-2.06E-02	-1.99E-02	6.576E-02	-2.60E-03	-3.66E-02	1.929E-02	-.890
Cleanliness	8.546E-02	3.773E-02	-1.27E-02	-4.34E-04	-1.69E-03	6.056E-02	-.815
Overall comfort	.230	.110	2.340E-02	-9.51E-02	-.213	2.931E-03	-.480

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 10 iterations.

Table 4:20 Total variance explained for OBLIMIN rotated components

Total Variance Explained				
	Initial Eigan values			Rotation
Component	Total	% Of Variance	Cumulative %	Total
1	11.7	43.3	43.3	6.8
2	1.6	5.8	49.1	5.7
3	1.4	5.3	54.4	5.6
4	1.2	4.6	59	6.5
5	1.1	3.9	62.9	6.7
6	1	3.7	66.6	4.3
7	0.8	3.1	69.7	6.9

Since the Varimax rotational method appears be a more universally accepted rotational method (Hair *et al,* 1995) and there is no real difference between the results of the Varimax rotational method and the Oblimin rotational method it was decided to continue the analysis with the Varimax rotational method.

4.7.2 Criteria for the significance of factor loadings

To be able to interpret the rotated components matrix it is important to identify the significance of the individual factor loadings. In assessing the significance of factor loadings, there are a number of possible approaches. The two main approaches that will be discussed in this thesis are practical significance and statistical significance.

Applying the practical significance criteria is based on figures derived from a rule-of-thumb approach.

> *"Factor loadings greater than ± 0.3 are considered to meet the minimum level; loadings of ± 0.4 are considered more important; and if loadings are ± there are 0.5 or greater, they are considered practically significant." (Hair* et al, *1995, p111)*

It is clear that using the practical significance criteria that the higher the factor loading the more significant the variable becomes. It is appropriate to use a practical significance criteria when the sample size is greater than 100 (Hair *et al,* 1995). Since the sample size for this research is 996, applying the practical significance criteria would be clearly appropriate. However, applying the practical significance criteria does not lead to statistically significant results. Identifying statistical significance is dependent upon the sample size. See Table 4:21 for guidelines for identifying significant factor loadings based on sample size[29] (Hair *et al,* 1995).

Table 4:21 Significant factor loadings based on sample size

Factor Loadings	Sample Size Need for Significance
0.3	350
0.35	250
0.4	200
0.45	150
0.5	120
0.55	100
0.6	85
0.65	70
0.7	60
0.75	50

By using the sample size as a basis for determining the factor loading significance, as can be seen in Table 4:21, the researcher can be confident that the results have a 0.05 level of significance. Since the highest sample size the table accommodates is 350, which corresponds to 0.3 factor loading, it was decided that any value less than 0.3 would be discounted. By using the value of 0.3 factor loading, both the practical significance criteria and the statistical significance criteria can be met.

[29] Significance is based on a 0.05 significance level (α), a power level of 80 per cent, and standard errors assumed to be twice those of conventional correlation coefficients. Source: computations made with Solo *Power Analysis*, BMDP statistical software, Inc, 1993.

Table 4:22 illustrates the Varimax orthogonal rotated component matrix with the factor loadings of value less than 0.3 removed.

Table 4:22 VARIMAX rotated component matrix with factor loading less than 0.3 removed.

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
Interruptions	.811						
Crowding	.726						
Noise	.663						
Privacy	.589				.337		
Overall atmosphere	.472	.303		.445			
Ventilation		.755					
Heating		.733					
Natural lighting		.701					
Artificial lighting		.664					
Personal storage			.790				
General storage			.706				
Workarea, Desk			.689				
Overall office layout	.363		.508			.357	.316
Position colleagues			.454	.383			.357
Circulation space			.372			.315	.320
Social Interaction				.874			
Work Interaction				.825			
Physical Security		.317		.529			
Creative physical environment	.346			.439	.308	.360	
Informal meeting areas					.834		
Formal meeting areas					.778		
Quiet areas					.727		
Decor						.802	
Cleanliness		.319				.751	
Overall comfort		.416	.349			.521	
Position equipment							.784
Refreshment							.720

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

4.7.3 Interpreting a factor matrix

Table 4:22 clearly demonstrates that variables cluster together and load onto the appropriate component. However, when a variable loads on to a number of components, criteria have to be established to enable a decision to be made as to which component the variable will be allocated. The highest loading for each variable is deemed to be the predominant loading. As an example, privacy, as can be seen in Table 4:22, has a factor loading of 0.589 on component one and a factor loading of 0.337 on component five. Therefore component one is chosen as the appropriate component for privacy and the 0.337 Factor loading is ignored. Applying this criterion of interpretation filters out unnecessary factor loadings.

Table 4:23 VARIMAX rotated component matrix with highest factor loading for each variable.

Rotated Component Matrix	Component						
	1	2	3	4	5	6	7
Interruptions	0.811						
Crowding	0.726						
Noise	0.663						
Privacy	0.589						
Overall atmosphere	0.472						
Ventilation		0.755					
Heating		0.733					
Natural lighting		0.701					
Artificial lighting		0.664					
Personal storage			0.79				
General storage			0.706				
Workarea, Desk			0.689				
Overall office layout			0.508				
Position colleagues			0.454				
Circulation space			0.372				
Social Interaction				0.874			
Work Interaction				0.825			
Physical Security				0.529			
Creative physical				0.439	0.308		
Informal meeting areas					0.834		
Formal meeting areas					0.778		
Quiet areas					0.727		
Decor						0.802	
Cleanliness						0.751	
Overall comfort						0.521	
Position equipment							0.784
Refreshment							0.72

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations

Table 4:23 illustrates the results from an orthogonal rotational solution with only the highest factor loadings for each variable retained. It is clear that all of the variables are retained, i.e. no variables have been filtered out in this process, and there are now clearly defined clusters of variables on the appropriate components. These clusters of variables are collectively measuring the corresponding component. This clearly illustrates that the 27 original variables have now been reduced to seven underlying dimensions. The next stage of analysis will be to consider the components created and to try to correlate them with theoretical dimensions. To assist in this process each component will be given a label.

To determine a label for a component, a pattern has to be established in the clustered variables.

> *"Variables with higher loadings are considered more important and have greater influence on the name or label selected to represent a factor." (Hair* et al, *1995, p114)*

The variables included in component one, such as interruptions, crowding, noise, privacy and overall atmosphere, indicate that this component is measuring some dimension related to interference or distraction (Mawson, 2002; Olson, 2002). Therefore it was decided to call this component ***distraction,*** as the variables loading onto this component appear to allow for a disruptive effect on the office occupiers' work performance.

The variables loading onto component two, such as ventilation, heating, natural lighting, artificial lighting, appear to be measuring an underlying dimension of occupier comfort relating to the building services (Oseland & Bartlett, 1999; Leaman & Bordass, 2000). Therefore this component was labelled ***environmental services***.

Component three has six variables loading on to it, such as personal storage, general storage, work area, overall office layout, position of colleagues and circulation space. The dimension that these variables are measuring appears to relate to the layout of the office, (Duffy, 1998). Therefore this component was labelled ***office layout***.

The fourth component consists of social interaction, work interaction, physical security and creative physical environment. It is the variables social interaction and work interaction that are the dominant variables in this component with factor loadings of 0.874 and 0.825 respectively, (Becker & Steele, 1995). Therefore this component appears to be measuring some form of interaction and therefore was given the label ***interaction.***

The variables loading onto the fifth component, such as informal meeting areas, formal meeting areas and quiet areas, clearly relates to different types of areas in an office (Becker & Steele, 1995; Duffy, 1998) Therefore it was decided that this component would be labelled ***designated areas.***

The sixth component which includes variables such as decor, cleanliness and overall comfort, appears to be linked by a dimension that is measuring the "softer" comfort elements as opposed to the previously identified "harder" comfort elements, i.e. environmental services (Oseland & Bartlett, 1999; Leaman & Bordass, 2000). Therefore this component was simply labelled ***comfort.***

The final component contains only two variables, i.e. position of equipment and refreshment, appears on first sight to not have any obvious reason to be together. However, considering the dynamics of an office environment, the position of fax machine, the printer and the tea point gives people the opportunity to chat informally. Therefore this component was labelled ***informal interaction points.***

At this stage of analysis there appears to be evidence to support hypothesis one.

> *Hypothesis One:*
>
> *Office productivity is a composite of the physical environment and the behavioural environment*

The components: environmental services, office layout, designated areas, informal interaction points and comfort all appear to be composites of the physical office environment whilst the components; interaction and distraction appear to represent the office environment from a behavioural view point. To add support to these components the next section will assess their reliability.

4.7.4 Reliability of factors

Having established the factors, and allocated appropriate names, the next part of the evaluation entailed establishing the robustness of the factors. To ensure that the factors created were consistent, and reliable, a Cronbach's alpha was calculated for the overall scale and for each individual factor. The results can be seen in Table 4:24.

Table 4:24 Seven factor analysis with Cronbach's alpha reliability scores

Factor	Name	Attributes	Cronbach's alpha
All			0.95
1	Distraction	Interruptions, crowding, noise, privacy, overall atmosphere	0.85
2	Environmental services	Ventilation, heating, natural lighting, artificial lighting	0.8
3	Office layout	Personal storage, general storage, work area, desk, overall office layout, position of colleagues, circulation space	0.85
4	Interaction	Social interaction, work interaction, physical security, creative physical environment	0.79
5	Designated Areas	Informal meeting areas, formal meeting areas, quiet areas	0.85
6	Comfort	Décor, cleanliness, overall comfort	0.87
7	Informal interaction points	Position of equipment, refreshment areas	0.57

A commonly accepted Cronbach's alpha is 0.7, although a value of 0.6 can be accepted during exploratory research (Hair *et al,* 1995). The results indicate a highly reliable overall Cronbach's alpha of 0.95. All of the individual factors indicate high internal reliability, except the informal interaction points factor, which has a Cronbach's alpha of 0.57. An explanation of such a low Cronbach's alpha could be that this factor only has two variables loading onto it, since generally the higher the number to variables loading on to a factor the higher the Cronbach's alpha. It was felt that at this stage of analysis the component revealed an insight into the dynamics of the office environment and therefore it was deemed acceptable, although it is acknowledged that the factor was not as reliable as the other factors in the analysis[30].

[30] The issue of internal reliability of the factors will be revisited in section 4.9.

4.8 Stage 6: Validation of factor analysis

This stage of the factor analysis aims to establish the robustness of the factors created. This can be achieved by establishing the generalisability of the factors and how well the factors represent a wider population.

> *"The most direct method of validating the results is to move to a confirmatory perspective and assess the replicability of the results either with a split sample in the original data set or with a separate sample." (Hair* et al, *1995, p114)*

To establish internal reliability for the seven components, factor analysis was conducted on a split sample of the original data set. To establish external reliability, and also the generalisability, of the components, factor analysis was conducted on a separate dataset, which was collected from the private sector.

4.8.1 Split sample factor analysis

The analysis so far has concentrated on the total results of office workers and their productivity. It should be noted that the total dataset consists of a number of different subsets. It is important to establish if the factors created in the total dataset are represented in the subsets, or whether the individual subsets create factors that are unique to that particular subset.

> *"The researcher must also ensure that the sample is homogeneous with respect to the underlying factor structure. It is inappropriate to apply factor analysis to a sample of males and females for items that are known to differ because of gender. When the two sub samples (males and females) are combined, the resulting correlations and factor structure will be a poor representation of the unique structure of each group. Thus, whenever differing groups are expected in the sample, separate factor analyses should be performed, and the results should be compared to identify differences not reflected in the results of the combined sample." (Hair* et al, *1995, p100)*

This stage of the analysis aims to establish how robust and generalizable the factors created by the total sample are, and if any nuances in the individual subsets have been lost. To achieve this, the purpose of analysis changes from being one of exploratory research to being one of a more confirmatory approach. The research aim is more confirmatory as the various subsets will be examined to establish the reoccurrence of the factors that were established in the total dataset.

The total dataset can be split into a number of different subsets, which were encompassed by two categories on the questionnaire. The two categories were:

i) About you, and

ii) Ways of working

The "about you" category consists of questions about gender, age and job type. The "ways of working" category consists of questions with regards to:

i) Time spent with colleagues

ii) Time spent in the office

iii) Flexibility as to where, when and how people work

iv)The variety of tasks that was undertaken when in the office.

It is the ways of working category that is of prime importance in this research, as it allows the total dataset to be split into a number of subsets that are comparable with the subsets that were created by the New Environments for Working research project (Laing *et al*, 1998). The NEW research project created a 2x2 matrix, which creates four unique ways of working models. The two variables used to create the matrix were degrees of autonomy and degrees of interaction.

The variables were defined as follows:

> ***Degrees of Interaction:*** *i.e. how much did office workers need to work or communicate face-to-face with their colleagues?*

Degrees of individual autonomy: *i.e. how much control does an employee have over the hours he or she works, the work location, the nature of the work, and the tools provided to do the work? (Laing* et al, *1998, p9)*

Subsequently Duffy redefines the variables as follows:

Interaction *is the personal face-face contact that is necessary to carry out office tasks. As the amount of interaction increases, there is more pressure to accommodate and support such encounters.*

Autonomy *is a degree of control, responsibility, and a discretion each office worker has over the content, method, location, and tools of the work processes.(Duffy, 1998, p60)*

Figure 4.4 illustrates the matrix and the labels given to the different ways of working.

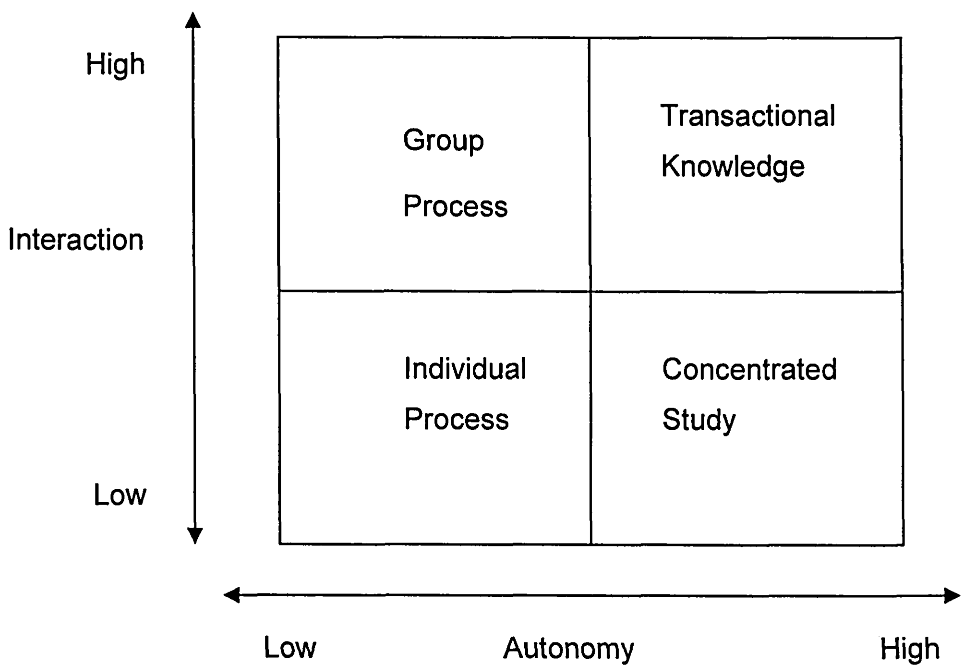

Figure 4.4 New ways of working (Adapted from Laing *et al*, 1998).

The original questionnaire was designed with specific questions about autonomy and interaction. Feedback from the piloting stage suggested that respondents were not comfortable with this type of wording; therefore the wording was changed whilst still maintaining the meaning.

To recreate the four different subsets, the following questions were asked:

i) What percentage of time do you spend with Colleagues?

ii) How much flexibility do you have to work where, when and how you wish?

The first question aims to establish the amount of interaction the individual has with their work colleagues when they are in the office. The second question aims to establish how much autonomy the individual has with regards to how they work.

Therefore the total dataset can be split into the corresponding comparable subsets using the criteria shown in Table 4:25.

Table 4:25 New ways of working criteria

Flexibility (Autonomy)	Time with Colleagues (Interaction)	Research Subsets	Sample Size
Very Low-Average	< 60 %	Individual Process	418
Very Low-Average	> 60 %	Group Process	302
High-Very High	< 60 %	Concentrated Study	184
High-Very High	> 60 %	Transactional Knowledge	93

The first column, in Table 4:25, allows the data set to be split based on the office occupiers perceived amount of work flexibility. Therefore, people who perceive themselves to be working with very low-average amount of flexibility, as to how, when and where they work, can be categorised as undertaking individual process or group process work. However, people who perceive themselves to have a high-very high amount of flexibility as to how they work in the office, can be categorised as undertaking either concentrated study or transactional knowledge ways of working.

The second column, in Table 4:25, allows the data set to be split based on the perceived amount of time spent with colleagues in the office environment. Respondents that perceive themselves to spend less than 60 per cent of their time working with colleagues can be categorised as either individual process and concentrated study workers. Alternately, respondents who perceive they spend more than 60 per cent of their time working with colleagues can be categorised as either group process or transactional knowledge workers.

The third column, in Table 4:25, illustrates the research subsets created from the previous two columns. The final column shows the sample size for the corresponding research subset.

Having created the four comparable subsets, a factor analysis was undertaken for each subset to establish if unique factors are created for each subset, or if the factors created in the total subset are reproduced in the subsets, thus supporting the validity and the generalisability of the original factors.

Since this part of the research process is more confirmatory, then each of the new ways of working subsets will be analysed with the factor analysis convergence model set at seven factors, and the factor loading cut-off set at the appropriate value that would represent a 0.05 significance level (Hair *et al,* 1995).

Table 4:26 Factor loading cut-off point for research subsets

Research Subsets	Sample Size	Factor Loading Cut-Off Point
Individual Process	418	0.3
Group Process	302	0.325
Concentrated Study	184	0.42
Transactional Knowledge	93	0.575

4.8.2 Transactional knowledge work

This type of work pattern is characterised by workers having a high-very high degree of flexibility as to when, where and how they work. They also spend a large percentage of their time, i.e. greater than 60 percent, working with colleagues.

Results of extracting seven factors can be seen in Table 4:27. Since physical security creates a component on its own, it is clearly evident that too many factors have been extracted.

Table 4:27 Seven factor analysis of transitional knowledge workers

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
Heating	.752						
Ventilation	.714						
Natural Light	.650						
General Storage	.578						
Artificial Light							
Personal Storage							
Decor		.847					
Cleanliness		.766					
Overall Comfort		.652					
Circulation Space							
Overall Office Layout							
Creative Physical Environment							
Workarea, Desk							
Interruptions			.827				
Crowding			.687				
Privacy			.663				
Noise							
Work Interaction				.832			
Social Interaction				.746			
Position Relative to Colleagues				.729			
Overall Atmosphere							
Formal Meeting Area					.837		
Informal Meeting Area					.815		
Quiet Areas					.715		
Refreshments						.846	
Position Relative to Equipment						.754	
Physical Security							.789

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 29 iterations.

The results of a Table 4:27 clearly demonstrate that the components created in the transactional knowledge work subset are not going to represent all the components created in the total sample. To establish how many components would represent this subset, a factor analysis was undertaken with the component convergence set at 6. The results can be seen in Table 4:28.

Table 4:28 Six factor analysis of transactional knowledge workers

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
Crowding	.750					
Interruptions	.696					
Noise	.647					
Personal Storage	.578					
Artificial Light						
Overall Atmosphere						
Workarea, Desk						
Privacy						
Overall Office Layout						
Creative Physical Environment						
General Storage						
Decor		.842				
Cleanliness		.752				
Overall Comfort		.608				
Circulation Space						
Informal Meeting Area			.822			
Formal Meeting Area			.796			
Quiet Areas			.745			
Social Interaction				.882		
Work Interaction				.854		
Position Relative to Colleagues						
Position Relative to Equipment					.747	
Refreshments					.734	
Natural Light						.677
Ventilation	.610					.626
Physical Security						
Heating						

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 15 iterations.

To allow comparison, the results for the total data set and the transactional knowledge data sets are presented in Table 4:29. The second column shows the attributes that are common to both the total data set and the transactional knowledge subset. The third column shows the attributes that are unique to the total data set, and the final column show the attributes that are unique to the transactional knowledge subset.

Table 4:29 Comparison of total data set with transactional knowledge data set

Factor	Common Attributes	Total Data Set	Transactional Knowledge Subset
Distraction	Interruptions, crowding, noise	Privacy, overall atmosphere	Personal storage
Environmental Services	Natural lighting, ventilation	Heating, artifical lighting	
Interaction	Social interaction, work interaction	Physical security, creative physical environment	
Designated Areas	Informal meeting areas, formal meeting areas, quiet areas		
Comfort	Decor, cleanliness, overall comfort		
Informal Interaction Points	Positon of equipment, refreshment		

By comparing and contrasting the results for the transactional knowledge workers with the results for the total sample, it can be seen that six of the components are clearly reproduced. Although it must be pointed out that not all the variables are present in Table 4:29. For example the total data set component environmental services consists of four variables, whereas in contrast the environmental services component for transactional knowledge workers only consists of two variables, i.e. natural light and ventilation. The reason why there are less variables appearing in the transactional knowledge worker subset is because some of the variables have been filtered out using the factor loading cut-off. Therefore, it is only the variables that have a significance level of 0.05 that remain.

The component that is not reproduced in the transactional knowledge worker subset is the office layout component. The absence of this component could be rationalised by the fact that the transactional knowledge worker has the flexibility to work wherever they feel appropriate to complete their work. Therefore they are not confined to working at a dedicated workstation but can work at various places within the office. If the transactional knowledge worker does not feel productive in the office environment they have the opportunity to work elsewhere, i.e. home working, teleworking etc. It is probably for these reasons that the component office layout does not appear as an underlying component for office productivity for the transactional knowledge worker.

The only variable to appear in the transactional knowledge worker subset that was part of the office layout component in the total sample dataset is personal storage. It is interesting to note that this variable loads onto the distraction component. This could probably be rationalised by the fact that the transactional knowledge worker has the advantage of flexibility and autonomy, but comes at the price of having fixed workspace and consequently lacks personal storage facilities.

4.8.3 Concentrated study Work

This type of work pattern is characterised by workers having a high-very high degree of flexibility as to when, where and how they work. They spend less than 60 percent of their time working with colleagues.

Results of extracting seven factors can be seen in Table 4:30.

Table 4:30 Seven factor analysis of concentrated study workers

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
Natural Light	.750						
Ventilation	.685						
Heating	.647						
Artificial Light	.633						
Physical Security	.484		.448				
Informal Meeting Area		.852					
Quiet Areas		.793					
Formal Meeting Area		.768					
Privacy		.509					
Social Interaction			.883				
Work Interaction			.814				
Overall Atmosphere			.551	.483			
Creative Physical Environment		.423	.539				
Interruptions				.799			
Crowding				.774			
Noise				.536			
Decor					.780		
Cleanliness					.760		
Overall Comfort	.425				.464		
Position Relative to Equipment						.733	
Refreshments						.699	
Circulation Space					.500	.560	
Position Relative to Colleagues			.447			.493	
Overall Office Layout						.424	
Personal Storage							.812
General Storage							.788
Workarea, Desk							.490

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

To allow comparison, the results for the total data set and the concentrated study data sets are presented in Table 4:31.

Table 4:31 Comparison of total data set with concentrated study data set

Factor	Common Attributes	Total Data Set	Concentrated Study Subset
Distraction	Interruptions, crowding, noise	Privacy, overall atmosphere	
Environmental Services	Natural lighting, ventilation, heating, artifical lighting		Physical security
Interaction	Social interaction, work interaction, creative physical environment	Physical security	Overall atmosphere
Designated Areas	Informal meeting areas, formal meeting areas, quiet areas		Privacy
Comfort	Decor, cleanliness, overall comfort		
Informal Interaction Points	Positon of equipment, refreshment		Circulation space, position of colleagues, overall office layout
Office Layout	Personal storage, general storage, work area - desk	Circulation space, position of colleagues, overall office layout	

By comparing and contrasting the results for the concentrated study worker with the results for the total sample, it can be seen that all seven components are reproduced. The noticeable difference is the loading of the variables, circulation space, position of colleagues and overall office layout on to the component Informal Interaction Points. These variables previously loaded onto the component office layout for the total dataset. Although these variables have loaded differently, the factor loading for each variable is very close to the factor loading cut-off point, which was set at a 0.42. Therefore the variables position relative to equipment and refreshments clearly dominate this component group with factor loadings of 0.733 and 0.699 respectively.

4.8.4 Group process work

This type of work pattern is characterised by workers having a very low-average degree of flexibility as to when, where and how they work. They spend more than 60 percent of their time working with colleagues.

Results of extracting seven factors can be seen in Table 4:32.

Table 4:32 Seven factor analysis of group process workers

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
Interruptions	.796						
Crowding	.759						
Noise	.644						
Privacy	.632						
Overall Atmosphere	.479	.331	.399				
Circulation Space	.414				.406		.371
Heating		.753					
Natural Light		.749					
Ventilation		.747					
Artificial Light	.354	.705					
Social Interaction			.865				
Work Interaction			.823				
Physical Security			.624				
Creative Physical Environment			.506			.357	
Personal Storage				.802			
General Storage				.742			
Workarea, Desk				.686			
Overall Office Layout	.373			.513			.382
Informal Meeting Area					.831		
Formal Meeting Area					.805		
Quiet Areas					.728		
Decor						.758	
Cleanliness						.682	
Overall Comfort		.464		.385		.495	
Position Relative to Equipment							.771
Refreshments							.638
Position Relative to Colleagues			.340	.404			.569

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

To allow comparison, the results for the total data set and the group process data sets are presented in Table 4:33.

Table 4:33 Comparison of total data set with group process data set

Factor	Common Attributes	Total Data Set	Group Process Subset
Distraction	Interruptions, crowding, noise, privacy, overall atmosphere		Circulation space
Environmental Services	Natural lighting, ventilation, heating, artifical lighting		
Interaction	Social interaction, work interaction, physical security, creative physical environment		
Designated Areas	Informal meeting areas, formal meeting areas, quiet areas		
Comfort	Decor, cleanliness, overall comfort		
Informal Interaction Points	Positon of equipment, refreshment		position of colleagues
Office Layout	Personal storage, general storage, work area - desk, overall office layout	Circulation space, position of colleagues	

Comparing the results for group process worker with the results for the total sample, it can be seen that all seven components are reproduced. The two variables, i.e. position of colleagues and circulation space had previously loaded onto the office layout component in the total sample dataset. The position of colleagues variable loading onto the informal interaction points could be rationalised by a the fact that this category of workers are most likely to work in groups or teams, therefore there is a high probability of informal chats between colleagues whilst sat at their desks (Olson, 2002). The circulation space loading on to the distraction component could be justified by the fact that the group process worker does not have the autonomy to work flexibly, and therefore people walking past their desk may cause some distraction to their work processes (Mawson, 2002).

4.8.5 Individual process work

This type of work pattern is characterised by workers having a very low-average degree of flexibility as to when, where and how they work. They spend less than 60 percent of their time working with colleagues.

Results of extracting seven factors can be seen in Table 4:34.

Table 4:34 Seven factor analysis of individual process workers

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
Ventilation	.799						
Natural Light	.705						.318
Heating	.653						
Artificial Light	.602						
Overall Comfort	.503	.319				.330	
Personal Storage		.765					
Workarea, Desk		.756					
General Storage		.643		.309			
Overall Office Layout	.311	.558	.337				.309
Position Relative to Colleagues		.539			.329		
Circulation Space		.495				.371	
Interruptions			.787				
Noise			.750				
Crowding		.369	.684				
Privacy	.335		.526	.375			
Overall Atmosphere	.356	.332	.434		.392		
Informal Meeting Area				.818			
Formal Meeting Area				.766			
Quiet Areas			.312	.712			
Social Interaction					.840		
Work Interaction					.815		
Creative Physical Environment			.314	.311	.437		
Physical Security						.726	
Cleanliness	.499					.597	
Decor	.420			.325		.549	
Refreshments							.766
Position Relative to Equipment					.332		.644

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

To allow comparison, the results for the total data set and the individual process data sets are presented in Table 4:35.

Table 4:35 Comparison of total data set with individual process data set

Factor	Common Attributes	Total Data Set	Individual Process Subset
Distraction	Interruptions, crowding, noise, privacy, overall atmosphere		
Environmental Services	Natural lighting, ventilation, heating, artifical lighting		Overall comfort
Interaction	Social interaction, work interaction, creative physical environment	Physical security	
Designated Areas	Informal meeting areas, formal meeting areas, quiet areas		
Comfort	Decor, cleanliness,	Overall comfort	Physical security
Informal Interaction Points	Positon of equipment, refreshment		
Office Layout	Personal storage, general storage, work area - desk, overall office layout, circulation space, position of colleagues		

Comparing the results for the individual process worker with the results for the total sample, it can be seen that all seven components are reproduced. The variable overall comfort previously loaded on to the comfort component in the total sample dataset. A possible explanation could be that individual process workers are office bound, which consequently puts a greater emphasis on their comfort being dependent on the quality of environmental services provision (Laing *et al*, 1998).

The variable physical security loads onto the component interaction for the total sample dataset. It is interesting to note that this variable loads on to the comfort component in the individual process worker dataset. This is significant since the factor loading for physical security is a 0.726 therefore clearly indicating that this variable dominates the comfort component for this data set. This indicates that for an individual process worker to feel comfortable in their working environment, there is a requirement for them to feel physically secure. This has implications for the provision of security for these types of workers.

4.8.6 Summary split sample factor analysis

This section has demonstrated that generally the seven components are replicable in three of the four different work patterns tested. Only the transactional knowledge worker data set does not replicate all the seven components, the missing component being office layout. The three new dynamic components, interaction, distraction and informal interaction points, are replicated in all of the work patterns demonstrating internal reliability.

4.8.7 Private sector factor analysis

This section uses a separate set of data collected from a Scottish brewery head office. The same questionnaire was used as a rerun of the questionnaire used in the public sector offices[31]. This section aims to establish the external reliability of the seven components, and the generalisability of the findings.

This section will be presented in the same format as previously established for the public sector factor analysis. Five stages of the factor analysis decision-making process will be presented as it relates to private sector data set.

---

[31] As general terms, public sector data will be used to refer to the local authority data set, and private sector data will be used to refer to the Scottish brewery head office dataset.

Stage 1: objectives of factor analysis

The aim of this part of the analysis is to establish the generalisability of the previously established seven factors. It is intended to that the analysis should move to a more confirmatory approach, enabling an assessment of the replicability of the established seven factors.

Stage 2: designing the factor analysis

As previously established this research aims to establish the underlying structure of the perception of variables, and therefore it is appropriate to apply R- type factor analysis. As the same questionnaire was used in this sample as for the previous sample, then all the previously established measurement issues are still valid. As previously established, an acceptable sample size would be 10 times the number of for variables (Hair *et al*, 1995), which would equate to 10 x 27= 270. The sample size of this data set was a 426 therefore clearly satisfying the minimum sample size requirement.

Stage 3: assumptions in factor analysis

This section aims to establish the appropriateness for conducting a factor analysis.

A visual inspection of the correlation matrix reveals that a substantial number of correlations were greater than 0.3 indicating the appropriateness of factor analysis (Appendix F). An examination of the commonality table (Table 4:36) reveals a range of values between 0.471 and 0.775, with 96 per cent of the commonality value being greater than 0.5. Since the majority of the commonalities are greater than 0.5, then further support for the acceptability of the data set for factor analysis is gained.

Table 4:36 Commonality table for private sector data set

Communalities

	Initial	Extraction
Workarea, Desk	1.000	.679
Personal Storage	1.000	.775
General Storage	1.000	.576
Formal Meeting Area	1.000	.613
Informal Meeting Area	1.000	.748
Quiet Areas	1.000	.750
Circulation Space	1.000	.583
Position Relative to Colleagues	1.000	.588
Position Relative to Equipment	1.000	.691
Refreshments	1.000	.656
Overall Office Layout	1.000	.656
Heating	1.000	.768
Natural Light	1.000	.622
Artificial Light	1.000	.538
Ventilation	1.000	.709
Noise	1.000	.696
Cleanliness	1.000	.591
Decor	1.000	.698
Overall Comfort	1.000	.686
Physical Security	1.000	.471
Social Interaction	1.000	.709
Work Interaction	1.000	.772
Creative Physical Environment	1.000	.601
Privacy	1.000	.619
Interruptions	1.000	.775
Crowding	1.000	.752
Overall Atmosphere	1.000	.732

Extraction Method: Principal Component Analysis.

The final visual inspection results relate to the anti-image correlation matrix (See Appendix G). This inspection consists of two parts, the first part being the inspection of the partial correlations. The majority of the partial correlations were low indicating acceptable data. The second part of the criterion relates to the diagonal values, which represent the individual variables Measure of Sampling the Adequacy (MS). All the MSA values were greater then 0.7 supporting the application of factor analysis.

The Bartlett test of Sphericity was highly significant ($p<0.01$)(Table 4:37), thereby supporting the probability that the correlation matrix has significant correlations among some of the variables. The Kaiser–Meyer-Olkin Measure of Sampling Adequacy (MS) was 0.917 putting this in the "marvellous category" of assessment, and giving strong indication of the acceptability of factor analysis.

Table 4:37 Kaiser-Meyer-Olkin and Bartlett's tests for private sector data set

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.917
Bartlett's Test of Sphericity	Approx. Chi-Square	5069.402
	df	351
	Sig.	.000

Having undertaken a range of assessments to ascertain the appropriateness of factor analysis, it can be concluded that there is significant evidence to support the appropriateness of using factor analysis on this data set.

Stage 4: deriving factors and assessing overall fit.

Since the aim of this stage of the analysis was to establish the replicability the previously identified seven factors, then the a priori criterion was used to determine the number of factors to be extracted. Table 4:38 shows the total variance explained for the seven components extracted. It can be seen that 67 per cent of the variance can be explained by the seven components. It should be noted that if the Latent root criteria for determining the number of factors had been used, then six components would have been extracted, representing 60 per cent of the total variance.

Table 4:38 Total variance explained using seven factor analysis on private sector data set

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.659	35.775	35.775	9.659	35.775	35.775	3.219	11.923	11.923
2	2.205	8.168	43.943	2.205	8.168	43.943	3.186	11.801	23.724
3	1.680	6.223	50.166	1.680	6.223	50.166	3.077	11.395	35.119
4	1.439	5.330	55.496	1.439	5.330	55.496	2.336	8.652	43.771
5	1.150	4.259	59.755	1.150	4.259	59.755	2.321	8.597	52.368
6	1.025	3.797	63.552	1.025	3.797	63.552	2.139	7.922	60.290
7	.894	3.310	66.862	.894	3.310	66.862	1.774	6.571	66.862
8	.779	2.885	69.747						
9	.738	2.732	72.479						
10	.687	2.545	75.024						
11	.682	2.526	77.550						
12	.605	2.242	79.792						
13	.556	2.057	81.850						
14	.541	2.002	83.852						
15	.476	1.762	85.613						
16	.453	1.678	87.292						
17	.440	1.628	88.920						
18	.414	1.532	90.452						
19	.371	1.373	91.825						
20	.364	1.346	93.171						
21	.334	1.237	94.408						
22	.324	1.200	95.608						
23	.290	1.076	96.684						
24	.258	.955	97.639						
25	.226	.838	98.476						
26	.212	.784	99.261						
27	.200	.739	100.000						

Extraction Method: Principal Component Analysis.

Stage 5: interpreting the factors

The same rotation method was used, i.e. VARIMAX, thereby replicating the same techniques that were adopted in the first dataset. A summary of the results can be seen in Table 4:39, which illustrates the components, their associated variables, and also the corresponding Cronbach's alpha.

Table 4:39 Seven factor analysis of private sector data set with Cronbach's alpha scores

Factor	Name	Attributes	Cronbach's alpha
All			0.93
1	Distraction	Interruptions, crowding, noise	0.78
2	Environmental services	Ventilation, heating, natural lighting, artificial lighting	0.78
3	Office layout	Personal storage, general storage, work area, desk, overall office layout, privacy	0.82
4	Interaction	Social interaction, work interaction, creative physical environment, overall atmosphere, position relative to colleagues	0.84
5	Designated Areas	Informal meeting areas, formal meeting areas, quiet areas	0.74
6	Comfort	Décor, cleanliness, overall comfort, physical security, circulation space	0.77
7	Informal interaction points	Position of equipment, refreshment areas	0.57

The results in Table 4:39 illustrate that generally the same seven factors are found in the private sector dataset, thereby supporting the notion that the factors are replicable. This result also supports the notion that both public and private sector office workers perceive the office in the same way when it comes to the components of office productivity. This finding supports the generalisability of the findings.

Also the majority of the components are of high internal reliability, i.e. with Cronbach's alpha greater then 0.7, although again it must be acknowledged that the component informal interaction points has a lower than normally accepted Cronbach's alpha.

To further support the generalisability of the components, and to also acknowledge the unique differences between the private and the public sector dataset, a comparison of results is shown in Table 4:40.

Table 4:40 Comparison of seven factor analysis for public sector and private sector data sets

Factor	Name	Common Attributes	Unique to Public Sector	Unique to Private Sector
All				
1	Distraction	Interruptions, crowding, noise	Privacy, Overall atmosphere	
2	Environmental services	Ventilation, heating, natural lighting, artificial lighting		
3	Office layout	Personal storage, general storage, work area - desk, overall office layout	Position relative to colleagues, Circulation space	Privacy
4	Interaction	Social interaction, work interaction, creative physical environment	Physical security	Position relative to colleagues, overall atmosphere
5	Designated Areas	Informal meeting areas, formal meeting areas, quiet areas, privacy		
6	Comfort	Décor, cleanliness, overall comfort,		Physical security, Circulation space
7	Informal interaction points	Position of equipment, refreshment areas		

Table 4:40 illustrates the common variables that are loaded on to the components, i.e. the same variables for the private and public sector. It also illustrates the unique variables that load differently for the private and public sector dataset, these being privacy, overall atmosphere, position relative to colleagues, circulation space and physical security.

Privacy and overall atmosphere load onto the distraction component for the public sector dataset, whereas for the private sector privacy loads with the office layout and overall atmosphere loads with interaction. It is an interesting observation to note that the public sector perceive overall atmosphere to be associated with distraction whereas in comparison the private sector perceive overall atmosphere to be associated with interaction. The private sector perceives position of colleagues to be attached to the component interaction, whilst the public sector perceives the position of colleagues to be attached to the office layout. The public sector perceives circulation space to be attached to the office layout whereas the private sector perceives it to be associated with comfort. The final unique variable is physical security. The public sector sees physical security in terms of interaction, whilst the private sector see physical security had been part of the comfort of their office environment.

Since both data sets generate comparable results, and in part preparation for further analysis, both of the data sets were combined to create an overall factor analysis. The results of the combined factor analysis can be seen in Table 4:41.

Table 4:41 Seven factor analysis for combined data sets with Cronbach's alpha scores

Factor	Name	Attributes	Cronbach's alpha
All			0.95
1	Distraction	Interruptions, crowding, noise	0.80
2	Environmental services	Ventilation, heating, natural lighting, artificial lighting	0.82
3	Office layout	Personal storage, general storage, work area - desk, overall office layout	0.86
4	Interaction	Social interaction, work interaction, , creative physical environment, overall atmosphere, position relative to colleagues	0.86
5	Designated Areas	Informal meeting areas, formal meeting areas, quiet areas, privacy	0.85
6	Comfort	Décor, cleanliness, overall comfort, physical security, circulation space	0.88
7	Informal interaction points	Position of equipment, refreshment areas	0.60

The results in Table 4:41 clearly illustrate the seven factors previously created in the public and private sector data sets. It should be noted that the three new factors, distraction, interaction and informal interaction points, are clearly established.

The overall Cronbach's Alpha indicates high internal reliability (0.95) and the majority of the factors having Cronbach's Alpha greater than 0.8. The Cronbach's Alpha for the Informal Interaction point has increased in value, relative to both the private and public sector data sets, to 0.6 indicating a higher internal reliability of this concept.

4.8.8 Summary private sector factor analysis

This part of the analysis has aimed to demonstrate that the seven components found in the public sector data set can be replicated in another set of data collected from the private sector. Three of the seven components are new, i.e. informal interaction points, interaction and distraction. The results demonstrate that both private and public sector office workers perceive the same underlying concepts with regards to office productivity. This supports the proposal that both public and private sector office workers have a common view of the underlying concepts of office productivity. Although it should be acknowledged that unique differences did appear, i.e. unique loading of certain variables, the general seven components remained robust. The acknowledgement that the factors are generalizable, from the public to the private sector, supports the proposal that both data sets can be combined to provide an overall factor analysis.

The private sector factor analysis results add further support for hypothesis one.

> *Hypothesis One:*
>
> *Office productivity is a composite of the physical environment and the behavioural environment*

The components: environmental services, office layout, designated areas, and comfort being composites of the physical office environment whilst the components; informal interaction points, interaction and distraction appear to capture the behavioural elements of the office environment.

The next section will further refine the concepts developed, in preparation for additional statistical analysis.

4.9 Stage 7: Scale Development

The previous analysis section established the underlying concepts with regards to office productivity in both the private and public sector. However, having created the new dimensions, the next stage is to use the dimensions to develop scales that can be used in subsequent statistical analysis. This progressive development can be considered as moving from purely factor interpretation towards a more data reduction methodology.

Ultimately the development of scales for the underlying concepts of office productivity will allow the evaluation of hypothesis two.

> *Hypothesis Two:*
>
> *It is the behavioural components of office productivity that have a greater effect on productivity than the physical components.*

When considering scale development two general options are available. The first option relates to using a single surrogate variable and the second option relates to the creation of a single composite measure.

A surrogate variable could be used to reduce the data as a way of representing the factor dimension. This approach uses the variable that has the highest factor loading as the representative for the dimension. The advantage of such an approach is that the selection process is relatively straightforward, and any subsequent analysis uses the single variable. The disadvantage of using a surrogate variable is that the richness of all the other variables loading onto the concept is lost. Also using a single variable allows a greater opportunity for measurement error, i.e. any error in the single variable transposing directly to the error measurement in the dimension. As a consequence of the disadvantages of using a surrogate variable, this form of data reduction was disregarded.

Having ruled out the use of a single surrogate variable then this leaves the creation of some kind of composite measure. There are two options that allow the creation of a single composite measure, factor scores and summated scales.

Factor scores are a single composite measure that can be created using SPSS, although their use has a number of disadvantages. The first disadvantage relates to the replication of the results; as the factor scores created relate to the specific factor matrix, the factor scores generated are not replicable to other studies. Another reported disadvantage of factor scores, relative to summated scales, is that their interpretation is relatively more difficult (Hair *et al*, 1995).

Summated scales can be defined as:

> *"In simple terms, all the variables loading highly on a factor are combined, and the total- or more commonly the average score of the variables is used as a replacement replicable variable." (Hair et al, 1995, p116)*

The use of the summated scale addresses some of the disadvantages that were established by using a surrogate variable, i.e. full representation of the concept by using all the appropriate variables and measurement error. The measurement error is reduced since multiple indicators (variables) are used, thereby reducing the reliance on a single variable. The creation of an average score of the variables allows a relatively straightforward approach to the interpretation of results and therefore addresses the disadvantage of factor scores.

It was therefore determined that summated scales would be used as a means of data reduction. The summated scale created was a composite measure, which consisted of the average score of all the variables loading onto the relative factor.

Having decided that summated scales were the appropriate data reduction method to adopt, there are a couple of issues, which will now be addressed, that are an integral part of the creation of the summated scale. These issues are concept definition and reliability.

The concept definition relates to the theoretical basis for the creation of the summated scales. However, as previously established, three of the seven of the components are totally new and therefore are contributions to knowledge. The three factors are: interaction, distraction and informal interaction points. Linked to concept definition is content validity, also known as face validity. The face validity of the four of the seven components, i.e. the ones that have some grounding in previous research, appears relatively high[32]. Although, it was felt that both validity and reliability could be improved if a different criterion was used for data extraction.

The Latent root criteria was used, as this was deemed to be in more robust criterion as only factors having a Latent roots, or eigenvalues, greater than 1 are considered significant.

Table 4:42 Total variance explained of combined dataset with Latent root criteria adopted

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.560	46.518	46.518	12.560	46.518	46.518	4.871	18.039	18.039
2	1.451	5.375	51.893	1.451	5.375	51.893	4.383	16.232	34.271
3	1.300	4.814	56.707	1.300	4.814	56.707	4.142	15.342	49.614
4	1.234	4.571	61.278	1.234	4.571	61.278	3.149	11.665	61.278
5	.965	3.574	64.853						
6	.938	3.473	68.326						
7	.779	2.884	71.210						
8	.711	2.635	73.844						
9	.632	2.341	76.185						
10	.573	2.121	78.306						
11	.548	2.029	80.335						
12	.534	1.976	82.311						
13	.518	1.919	84.229						
14	.433	1.605	85.835						
15	.416	1.542	87.376						
16	.409	1.517	88.893						
17	.362	1.342	90.235						
18	.341	1.264	91.499						
19	.331	1.227	92.726						
20	.303	1.122	93.848						
21	.273	1.010	94.858						
22	.267	.990	95.848						
23	.249	.923	96.770						
24	.241	.891	97.662						
25	.233	.862	98.523						
26	.218	.806	99.330						
27	.181	.670	100.000						

Extraction Method: Principal Component Analysis.

As can be seen in Table 4:42 using the Latent root criterion, only four factors are created. The four factors explain 61.3 per cent of the total variance. Whilst factors five and six have values greater than 0.9, they have been removed from the final factor solution.

A comparison of the previous seven factor solution and the new four factor solution can be seen in Table 4:43. Generally six of the previous seven factors have converged to create three more generic factors. Integrating the previous comfort factor, and the environmental services factor to create a new comfort factor. The new office layout factor is created by integrating the previous office layout and

[32] This assertion relates more to conceptual dimensions in the literature, rather than research evidence of dimensions.

designated areas. Integrating the previous interaction factor with informal interaction points creates the new interaction factor. The distraction factor is the same as the previous distraction factor.

Table 4:43 Comparison of seven factor and four factor solutions for combined dataset

Factor	Name	Attributes	Cronbach's alpha	Previous Factors
All			0.95	
1	Comfort	Ventilation, heating, natural lighting, artificial lighting, dėcor, cleanliness, overall comfort, physical security,	0.89	Comfort Environmental Services
2	Office layout	Informal meeting areas, formal meeting areas, quiet areas, privacy, personal storage, general storage, work area - desk and circulation space	0.89	Office Layout Designated Areas
3	Interaction	Social interaction, work interaction, creative physical environment, overall atmosphere, position relative to colleagues, position relative to equipment, overall office layout and refreshments	0.88	Interaction Informal Interaction Points
4	Distraction	Interruptions, crowding, noise	0.80	Distraction

Three of the new factors created have eight variables loading onto them. A visual inspection of the variables, and the factors, identifies only one variable that appears out of line with the dimension of measurement; that variable being overall office layout, as it is loaded with interaction rather than the dimension office layout. It was decided to accept this ambiguity and still include the variable in the measurement of the concept. Generally the remaining variables appear to load onto appropriate factors. This approach can be considered as an assessment of face validity.

> *"The crudest method of checking a test's validity is simply to inspect the contents to see whether it does indeed measure what it is supposed to."(Coolican, 1999, p173)*

Based on this procedure, it could be argued that the face validity of the three of the four dimensions (interaction, office layout and comfort) have increased relative to the previous seven factor solution. The dimension distraction is the only dimension to have remained completely intact after the subsequent data deduction method.

It should be also noted that the new factors all have Cronbach's Alpha results of 0.8 or greater, indicating high internal reliability (Hair *et al*, 1995).

The previous informal interaction points factor, which had a Cronbach's Alpha of 0.6, has now been absorbed into the new interaction factor, which has a Cronbach's Alpha of 0.8.

Ultimately the four factors created appear to demonstrate higher face validity, and also an increased internal reliability, therefore creating a more robust scale, which will be used as the basis for further statistical analysis.

This section has refined the components of office productivity in preparation for subsequent analysis.

The four dimensions created allow comparisons to be made with the tangible elements of an office environment with the intangible elements. The tangible elements are represented by office comfort and office layout, and the intangible elements are represented with interaction and distraction. It is the interaction and distraction dimensions that add to the debate with regards office productivity, and contribute to knowledge, as they start to enable office designers and managers to understand the dynamic nature of the office.

It is proposed that the four new components add further support to hypothesis one. Since the components office layout and comfort appear to support the proposition that the office environment can be perceived as the physical environment (Oseland

1999 and 2004 and Leaman and Bordass, 2000) and distraction and interaction appear to support the proposition that the office environment can be perceived as a behavioural environment. (Olson, 2002; Nathan and Doyle, 2002).

> *Hypothesis One:*
>
> *Office productivity is a composite of the physical environment and the behavioural environment*

The research findings provide evidence to support a validated theoretical framework as can be seen in Figure 4.5.

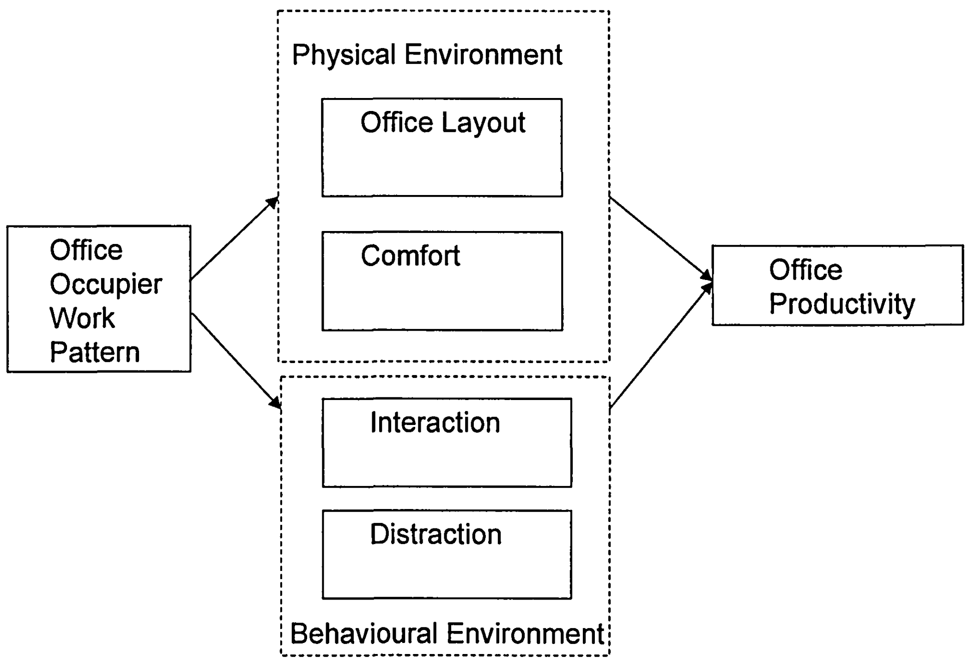

Figure 4.5 Validated theoretical framework of office productivity

Having established the validity and the reliability of the four dimensions of office productivity, the next section will present the initial results of the dimensions.

4.9.1 Initial analysis

This section will use the summated scales for the four dimensions of office productivity to evaluate hypothesis two.

> *Hypothesis Two:*
>
> *It is the behavioural components of office productivity that have a greater effect on productivity than the physical components.*

Table 4:44 illustrates the relative distributions for each of the four concepts for the total dataset. The median values for comfort and layout are both the same, with a value of 2.75, indicating slightly skewed negative distributions. These results indicate that at best the office layout and comfort level in the office environment are having a neutral effect on productivity. There is an opportunity to improve office productivity by reviewing both the office comfort and layout for all office occupiers.

Table 4:44 Percentile results for the four office productivity components

Statistics

		COMFORT Comfort	LAYOUT Office Layout	INTERACT Interaction	DISTRACT Distraction
N	Valid	1410	1413	1412	1410
	Missing	8	5	6	8
Percentiles	25	2.2500	2.2500	2.6250	1.6667
	50	2.7500	2.7500	3.1250	2.3333
	75	3.3750	3.3750	3.6250	3.0000

The interaction results appear to be the most positive for all the dataset with a median of 3.13 and an upper quartile result of 3.63. The fourth concept (distraction) has the most negatively skewed distribution and has a median value of 2.33 and an upper quartile value of 3.0.

A graphical representation of the results can be seen in Figure 4.6. Comparing the four concepts it can be seen that the interaction concept results have the most positive distribution and the distraction concept has the most negative results. This result in itself contributes to knowledge as it illustrates that it is the components that relate to the office dynamics that have the most effect on productivity (Nathan and Doyle, 2002).

1409

Comfort Office Layout Interaction Distraction

Figure 4.6 Box plot results for four factors.

Whilst this section has provided initial support for the hypothesis that it is the behavioural environment that has the greatest effect on productivity, the next chapter will evaluate this hypothesis for each of the four different work patterns: individual process, group process, concentrated study and transactional knowledge work (Laing *et al,* 1998).

4.10 Conclusion

This chapter has evaluated the main hypothesis that office productivity is a composite of the physical environment and the behavioural environment. Factor analysis has been used to develop a model to represent office productivity. Factor analysis has allowed the initial 27 evaluative variables, used in the study, to be reduced to the underlying concepts of office productivity. To demonstrate rigour of evaluation, two sizable data sets were used. The first data set was obtained from local authority offices, whist the second data set was obtained from offices in a Scottish brewery head office buildings. Analysis of both the data sets confirmed that seven components could be created, using factor analysis, to represent the concept of office productivity. The seven components created were: environmental services, office layout, designated areas, informal interaction points, comfort, interaction and distraction.

It is proposed that the components, environmental services, office layout, designated areas and comfort are representative of the physical environment (Whitley, 1996, Oseland, 1999, 2004; Leaman and Bordass, 2000), whilst the components distraction, interaction and informal interaction points relate more to the behavioural environment. Although the physical components support exiting literature, the three behavioural components are new and therefore contribute to the body of knowledge.

The creation of the seven components appears to offer support for the hypothesis that a model can be developed to represent the concept of office productivity, with the dimensions of physical environment and behavioural environment.

However, whilst the seven components create meaning and understanding of office productivity, the office productivity model was reduced to four components to allow a more robust statistical analysis to be undertaken. The four components allow the physical environment to be represented by office layout and comfort, whilst the behavioural environment is represented by interaction and distraction.

Finally, this chapter uses summated scales to measure the four components of office productivity for all office respondents. The initial analysis of all respondents provides support for the hypothesis that it is the behavioural components that have the greatest effect on office productivity. This finding is a further contribution to knowledge as it develops a greater understanding of the social dynamics, and the behavioural patterns, that exist in the office environment (Nathan & Doyle, 2002).

Chapter 5

Discussion of Results

5 Discussion of Results

5.1 Introduction

This discussion of results aims to use the four components, previously derived, as new evaluative variables. The components will be used as the basis of analysis, set against the context of the four different work patterns; individual process, group process, concentrated study and transactional knowledge (Laing *et al,* 1998). The work pattern samples were established as subsets of the total dataset (Table 5:1).

Table 5:1 Work patterns adopted for this study

Way of Working	Flexibility (Autonomy)	Time with Colleagues (Interaction)	Sample Size
Individual Process	Very Low-Average	< 60 %	606
Group Process	Very Low-Average	> 60 %	425
Concentrated Study	High-Very High	< 60 %	252
Transactional Knowledge	High-Very High	> 60 %	116

The analysis consists of two major components. The first part of the analysis will use exploratory data analysis techniques to evaluate the components within each of the four work patterns. The aim is to establish which of the four components, for each of the work patterns, has the most effect on the office occupiers' productivity, and to establish if the effect is positive or negative. It is intended that this section of analysis will evaluate hypothesis two:

> *Hypothesis Two:*
>
> *It is the behavioural components of office productivity that have a greater effect on productivity than the physical components.*

The second part of the analysis applies a range of confirmatory statistical techniques, using the four components as common metrics of analysis. This approach allows statistical comparisons to be made between the work patterns and the components. It is intended that this section of analysis will evaluate the hypothesis three:

> *Hypothesis Three:*
>
> *There is no significant difference between work patterns in terms of office productivity.*

This chapter will conclude with summary of the results of the two hypotheses tested.

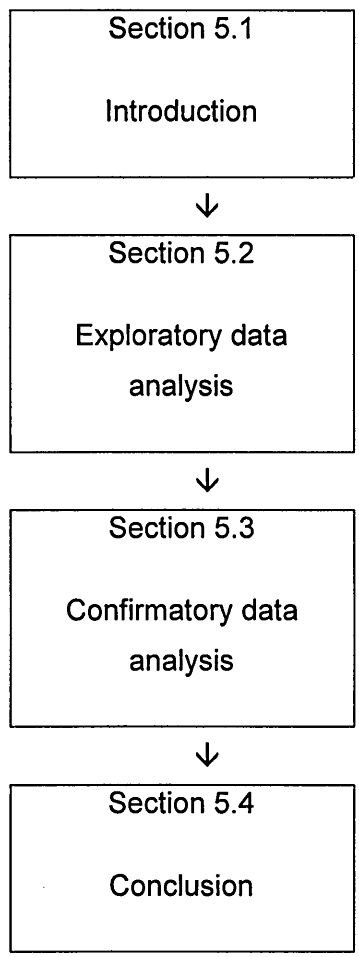

Figure 5.1 Structure of Chapter 5

5.2 Exploratory work pattern data analysis

5.2.1 Introduction

This section aims to explore the results of each of the different work patterns to establish the effects of office environments on their perceived productivity. This section will apply exploratory data analysis techniques to evaluate Hypothesis two in the context of each of the four defined work patterns.

Hypothesis Two:

It is the behavioural components of office productivity that have a greater effect on productivity than the physical components.

The aim of this research was to establish that it is the different forms of communication, specifically conversation, that are the currency of a productive office[33]. Therefore it will be factors that enable interaction to occur, that will be seen as the factors that have the most positive impact of on office productivity.

The term exploratory data analysis is used as this section aims to summarise data, in a tabulated and graphical form, and establish relationships within each work pattern, which may not be apparent in the raw data (Hussey & Hussey, 1997).

The format of the analysis for each of the four work patterns is the same. Firstly, the demographic data, which is established from the categorical questions, is presented in a tabulated format. The interpretation of the demographic data allows a profile of the work pattern type to be established. Secondly, the evaluative variables, the four components of comfort, office layout, distraction and interaction, are presented in a box plot format with accompanying analysis and interpretation. The box plot is an appropriate means for presenting the data, as it allows the four distributions to be presented along side each other, thereby allowing, at a glance, variation in the central level and the spread of the data to be established (Dunleavy, 2003).

[33] The notion that conversation is the currency of the modern organisation is accredited to Price and Shaw (1998)

Hussey and Hussey (1997) define a box plot as follows:

> *"A box plot is a very useful diagram that presents four important measures of dispersion and one of location and illustrates the shape of a frequency distribution: the upper and lower extremes, the median and the upper and lower quartiles. The 'box' represents the middle 50 percent of the data and each 'whisker' represents 25 percent." (Hussey & Hussey, 1997, p211)*

Dunleavy (2003) also supports the benefits of presenting data in a box plot format, especially in a PhD thesis, by making the following observation:

> *"This is a sophisticated, multi-indicator comparison, yet accomplished in a very intuitive and accessible way. It can greatly assist your understanding of the data, and it can also convey a lot of information effectively to the readers." (Dunleavy, 2003, p189)*

This section is brought to an end with the inclusion of a summary element. The summary aims to pull together the salient points that have been established throughout the analysis and interpretation of the four work pattern results.

5.2.2 Individual process work

The individual process worker category is defined as occupiers that spend less than 60% of their time with colleagues, and have very low - average degree of flexibility to work where and how they wish. The demographic results for individual process workers can be seen in Table 5:2.

Table 5:2 Demographic results for individual process workers

		Individual Process Work
Type of Sector	Private Sector	31
	Public Sector	69
	Total	100
Type of Office	Cellular	16
	Open Plan	83
		1
	Total	100
Dedicated Desk	Yes	96
	No	4
		1
	Total	100
Gender	Male	44
	Female	54
		2
	Total	100
Age of Respondent	<25	5
	25-35	32
	36-45	31
	46-55	25
	>55	7
	Total	100
Time in the Office	0-20	1
	21-40	7
	41-60	16
	61-80	16
	81-100	59
	Total	100
Variety of tasks undertaken in the office	Very Low	2
	Low	9
	Average	48
	High	32
	Very High	8
	Total	100
Overall Importance	Very Low	1
	Low	2
	Average	19
	High	52
	Very High	25
	Total	100

The majority of individual process workers are less than 45 years old (68%), with the modal category of respondents being the 25-35 years age group (32%). The result indicates a relatively young workforce undertaking individual process work. The sample is biased towards the female population with 54% of respondents being female and 44 % being male.

The sample of individual process workers is comprised of private and public sector workers, 31 % and 69% respectively. Whilst the results show that the majority of individual process workers work in open-plan offices (83%), it should be noted that a small percentage report to work in cellular offices (16%). The results also indicate that there is virtually no flexible working in the office, with 96% of individual process workers reporting to have a dedicated desk. The results offer some support to the notion that the office environment for the individual process worker can be classified as the hive office organisation (Laing *et al,* 1998*)*.

> *"The hive office organization is characterized by individual routine process work with low levels of interaction and individual autonomy. The office worker sits at simple workstations for continuous periods of time on a regular 9 to 5 schedule (variants of this type include 24-hour shift working". (Laing et al, 1998, p21)*

However, there are signs that some flexibility exists outside the office, with 25% of respondents reporting that they spend less than 60% their time in the office, but the majority of individual process worker respondents report to spend more than 60% of their time in the office (75%). When in the office, 60 % of individual process workers report to be undertaking very low to average variety of tasks. This result supports the notion that individual process workers undertake repetitive work (Laing *et al, 1998)*.

Evaluative Variables

The relative distributions for each of the four components for the work pattern individual process work can be seen in Figure 5.2.

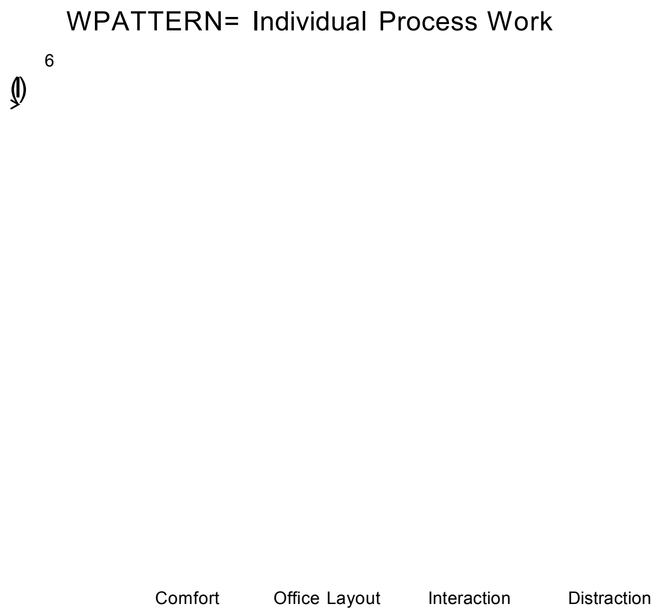

Figure 5.2 Box plots of evaluative variables for individual process work

The results for comfort and layout produce similar distributions with a slightly skewed distribution towards the negative, and both have median values of 2.75. This could be interpreted as a level of dissatisfaction with the layout of the office and the comfort systems it contains. The interaction results, with a median of 3.0, tend to indicate a neutral response with the inter-quartile range being around the neutral point. The fourth component (distraction) has the least median value of all the four factors (2.33), and clearly illustrates a negatively skewed distribution with an upper quartile value of 3.0. Comparison of the four components indicates that the distraction component appears to be having the most effect on productivity, that effect being relatively more negative. The sub components of distraction are crowding, noise and interruptions. There is a requirement for clear strategies to be adopted to minimise the negative effect on individual process workers productivity.

The results indicate that when it comes to individual process workers, there is a clear opportunity to improve productivity by considering the physical components of the office, those being office comfort and office layout. The proposal that this type of worker can work in a hive format layout, with limited control over heating, lighting and ventilation etc, should be questioned (Laing *et al*, 1998).

The dynamic component of distraction reveals an issue that may be addressed by considering the office protocols (Sims, 2000; Brennan *et al*, 2002). Since individual process workers have little flexibility in the office environment it is important the office environment is actively managed to support the occupiers in their work (Bradley, 2002; Laframboise *et al*, 2003).

The results question the requirement for individual process workers to be constantly in the office, since they spend relatively little time interacting with colleagues. Whilst it is acknowledged that this proposal would question the workplace culture (Turner & Myerson, 1998), it is supported by other research, which established that home-based contact centre workers produced higher productivity than comparable contact centre workers (Wright, 2002). The research also established the benefits of maintaining interaction with both team members and team leaders as a way of maintaining a feeling of belonging. A disadvantage, identified by the research, was a perception that being home-based working could have a negative effect on your career development. Wright (2002) established that home-based workers felt that by being out of sight they were out of mind, when it came to job promotions. By considering flexible working for individual process workers the negative effect of the component distraction could be reduced (Olson, 2002).

To enhance the positive effects of interaction, consideration should be given to the creation of interactive areas such as break out space (Peterson & Beard, 2004). This result is in contrast to the purely regimented hive layout for individual process workers as proposed by Laing *et al* (1998).

The results for the individual process workers, in contrast to Laing *et al* (1998), support the hypothesis that it is the behavioural components of the office environment that have the greatest effect on productivity.

5.2.3 Group process work

The group process worker category is defined as occupiers that spend more than 60% of their time with colleagues, and have very low - average degree of flexibility to work where and how they wish. The demographic results for group process workers can be seen Table 5:3.

Table 5:3 Demographic results for group process workers

		Group Process Work
Type of Sector	Private Sector	31
	Public Sector	69
	Total	100
Type of Office	Cellular	18
	Open Plan	81
		1
	Total	100
Dedicated Desk	Yes	97
	No	2
		0
	Total	100
Gender	Male	33
	Female	66
		1
	Total	100
Age of Respondent	<25	5
	25-35	30
	36-45	29
	46-55	30
	>55	6
	Total	100
Time in the Office	0-20	0
	21-40	3
	41-60	4
	61-80	13
	81-100	80
	Total	100
Variety of tasks undertaken in the office	Very Low	3
	Low	4
	Average	47
	High	33
	Very High	14
	Total	100
Overall Importance	Very Low	1
	Low	4
	Average	18
	High	47
	Very High	30
	Total	100

The majority of group process workers are less than 45 years old (64%) The result indicates a relatively young workforce undertaking group process work and is similar to the individual process worker results. The sample is heavily biased towards the female population with 66% of respondents being female and 33 % being male. This result, along with the individual process worker results, indicates that process work appears to be a work type that is dominated by female staff.

Whilst the results show that the majority of group process respondents work in open-plan offices (81%), it should be noted that a small percentage report to work in cellular offices (18%). The results also indicate that there is virtually no flexible working in the office, with 97% of group process workers reporting to have a dedicated desk. There is little evidence of flexibility outside the office, with only 7% of respondents reporting that they spend less than 60% of their time in the office, and the majority of group process worker respondents report to spend more than 60% of their time in the office (93%). When in the office, 47% of group process workers report to be undertaking average variety of tasks and a further 47% report to be undertaking high to very high variety of tasks. However, the results generally support the proposal that group process work be undertaken in an open-plan environment (Laing *et al*, 1998).

> *"The den office organization is associated with group process work, interactive but not necessarily highly autonomous. The space is designed for group working with a range of several simple settings, typically arranged in the open-plan or group room." (Laing et al, 1998, p23)*

Evaluative Variables

The relative distributions for each of the four components for the work pattern group process work can be seen in Figure 5.3.

WPATTERN= Group Process Work

Comfort Office Layout Interaction Distraction

Figure 5.3 Box plots of evaluative variables for group process workers

The median values for comfort and layout are both the same, with a value of 2.75, indicating slightly skewed negative distributions, although the upper quartile is more positive for the office layout results than the comfort results with values of 3.5 and 3.38 respectively. These results indicate that there is an opportunity to improve office productivity by reviewing the office comfort and layout provided for group process workers.

The interaction results appear to be the most positive for the group process workers with a median of 3.13 and an upper quartile result of 3.63. It is understandable that the group process workers value interaction as they spend more than 60% of their time with colleagues. The fourth component (distraction) has the most negatively skewed distribution and has a median value of 2.33 and an upper quartile value of 3.0. The distraction results, for the group process workers, follow the same profile as the individual process workers indicating a common issue for both individual and group process workers.

Comparing the four components it can be seen that the interaction component results have the most positive distribution and the distraction component has the most negative results, thereby providing supporting evidence for hypothesis two. Once again these results follow the same format as for the individual process worker, although managing interaction and distraction for group process workers may require a different strategy than the one required for individual process workers.

The results indicate a profile for the group process worker that consists of 93% of respondents spending more than 60% of their time in the office and spending more then 60% of their time interacting with colleagues. This profile suggests that the group process worker is largely location required. This requirement, to be constantly in the office, clearly puts a high demand on ensuring that the comfort and the office layout are designed correctly. Sims (2000) reports the benefits of designing space around teams, called team space, in workstation clusters. This approach aims to achieve an increase in communication and shared learning. The practice of "creative eavesdropping" is encouraged as a way of achieving these objectives. AMOCO adopted these concepts, and report a 25% reduction in cycle times and a 43% reduction in space requirement (Sims, 2000). Clearly, if consideration is given to how groups or teams work together, and space designed around these needs, then an increase in productivity can be achieved.

The design of the office environment will need to enable optimum interaction whilst maintaining distraction to a minimum. This creates a paradox, as the group process workers are constantly in the office, having face-to-face interaction with their colleagues. The creation of team spaces, as previously suggested, should help, as this should keep interactions localised to the team, and minimise distraction from other teams or group workers. Group process work largely involves other office occupiers; therefore consideration should be given to the provision of quiet, private areas (Peterson & Beard, 2004).

Whilst office layout can greatly improve the effect of distraction and interaction, there comes a point where any further improvement can only be achieved by ensuring the people know how to use the space. There is a requirement for clear protocols about how the space is to be used and how people should conduct themselves in the spaces created (Brennan *et al*, 2004; Sims, 2000). Therefore there is a need to accept the office environment for group process workers to be a dynamic place, which needs to be clearly managed, with explicit instruction given as to how various parts of the office are designed to work. Failure to undertake this kind of awareness training can led to unnecessary dissatisfaction, simply because people were never shown how to use the office environment (Pugsley & Haynes, 2002).

It can be concluded that the results for group process workers support the hypothesis that it is the behavioural components of the office environment that have the greatest effect on productivity.

5.2.4 Concentrated study

The concentrated study worker category is defined as occupiers that spend less than 60% of their time with colleagues, and have high – very high degree of flexibility to work where and how they wish. The demographic results for group process workers can be seen in Table 5:4.

Table 5:4 Demographic results for concentrated study workers

		Concentrated Study Work
Type of Sector	Private Sector	28
	Public Sector	72
	Total	100
Type of Office	Cellular	23
	Open Plan	76
		1
	Total	100
Dedicated Desk	Yes	91
	No	8
		1
	Total	100
Gender	Male	61
	Female	38
		1
	Total	100
Age of Respondent	<25	4
	25-35	30
	36-45	30
	46-55	28
	>55	8
	Total	100
Time in the Office	0-20	3
	21-40	15
	41-60	32
	61-80	25
	81-100	25
	Total	100
Variety of tasks undertaken in the office	Very Low	1
	Low	4
	Average	40
	High	45
	Very High	10
	Total	100
Overall Importance	Very Low	0
	Low	4
	Average	24
	High	51
	Very High	21
	Total	100

The age profile for concentrated study workers follows the same format as the individual process and group process worker profiles, with the majority of concentrated study workers being less than 45 years old (64%). This result indicates that the age of the respondent and the type of work pattern are not associated with age.

The sample is heavily biased towards the male population with 61% of respondents being male and 33 % being female. This result, along with the individual process and group process worker results, indicates that a relationship could exist between the work pattern and the gender of the respondent.

The concentrated study respondents report more cellular offices than individual process and group process workers (23%), although the majority of concentrated study workers work in open-plan (76%). This result is in contrast to the proposal that concentrated study workers should work in cellular offices (Laing *et al,* 1998).

The results for the time spent in the office indicate that 50% of the concentrated study respondents spend less than 60% of their time in the office. This is an indication that not only do concentrated study workers perceive themselves to have more flexibility than the individual process and group process respondents, but that they also act on that flexibility. The results offer some support to the proposal that concentrated study workers can occupy a range of different locations (Laing *et al,* 1998).

> *"The cell office organization is for individual concentrated work with little interaction. Highly autonomous individuals occupy the office in an intermittent irregular pattern with extended working days, working elsewhere some of the time (possibly at home, at clients, or on the road)." (Laing et al, 1998, p22)*

With 50% of concentrated study respondents spending less than 60% of their time in the office there appears to be an opportunity to undertake flexible working practices such as hot-desking or hotelling, although the results for dedicated desks indicate that only a small percentage undertake flexible working practices within the office environment, with only 8% reporting to have a non dedicated desk.

When in the office, 40% of concentrated study respondents report to be undertaking an average variety of tasks, and a further 55% report to be undertaking high to very high variety of tasks. Compared with the individual process and the group process workers, the concentrated study workers report the most variety of tasks, although the tasks are largely undertaken on an individual basis.

Evaluative Variables

The relative distributions for each of the four components for the work pattern concentrated study work can be seen in Figure 5.4.

WPATTERN= Concentrated Study Work

252 252

Comfort Office Layout Interaction Distraction

Figure 5.4 Box plots of evaluative variables for concentrated study work

The distribution for the comfort component indicates a relatively even distribution with median value of 3.0 and an inter-quartile range between 2.13 and 3.38. The office layout component has a slightly more negative distribution than the comfort distribution, with a median of 2.88. Although 50% of concentrated study respondents spend less than 60% of their time in the office, when in the office the comfort and layout results indicate that it is not an environment designed to enhance their productivity.

Although the concentrated study worker category is defined as office occupiers that spend less than 60% of their time with colleagues, the interaction distribution is the most positive for the concentrated study respondents, with a median of 3.25 and an upper quartile result of 3.63. This is an indication that whilst concentrated study workers largely work on their own, interactions are valued as having a positive effect on their productivity; this could be a chance conversation in a corridor or over a coffee (Haynes & Price, 2004).

Of all the components, the distraction component has the most negatively skewed distribution, with a median value of 2.33 and an upper quartile value of 3.0, indicating distraction to be the component to having the most effect on perceived productivity (Olson, 2002). Comparing the four components it can be seen that the interaction component results have the most positive distribution and the distraction component has the most negative results.

The concentrated study respondents' profile illustrates that only 25% of concentrated study workers report to spend between 81-100% of their time in the office. The remaining concentrated study respondents are adopting some form of flexible working to a larger or lesser degree. Also, with 91% of concentrated study respondents reporting to have a dedicated desk, there is clearly an opportunity for increased efficiency in space allocation (Peterson & Beard, 2004). The possibility exists for an increase in more shared individual space, but at a higher specification than is currently being experienced by the concentrated study respondents. This increase in the right kind of individual space should also address the physical issues with regards to comfort and layout. However, to allow a higher quality of individual space, consideration should be given to how the space is to be managed. Integrated into the management of the office space, should be consideration for the amount of interaction and distraction allowed by the utilisation of the space. Probably the most appropriate workplace strategy for a concentrated study worker would be hotelling, since they have the flexibility to work in a manner that is appropriate to their needs. Therefore they could plan and book concentrated study areas as and when they were required.

The results indicate a poor space utilisation with only 25% of concentrated study respondents spending between 81-100% of their time in the office, and 91% of concentrated study respondents reporting to have a dedicated desk. With these kinds of results it is understandable why FM managers see that cost reduction can be achieved by providing less space (Haynes *et al,* 2000). The opportunities to save space, and ultimately cost reduction, are further supported by The RICS report “Property in Business a Waste of Space” which claims that:

> *"Hot desking " and other new working practices could save British business a further £6.5 billion a year." (Bootle & Kalyan, 2002)*

However, recent research has established that a preoccupation with just cost reduction could have an overall negative effect on the business performance (Becker & Pearce, 2003). They present an argument that, cost savings gained, due to property decisions could be more than wiped out by negative effects on the organisation's productivity.

Gibson (2003) identifies this potential tension between the cost reduction driver and the desire to create a working environment that supports the work processes.

> *"The consequences of new working practices for office space are twofold. On the one hand, if staff are working from non-traditional locations (home, clients' offices, their car) there may be the potential for a reduction in the total office space required and a resulting reduction in occupation costs. On the other hand, the space that is provided is likely to have a rather different function and therefore needs to be designed and managed in different ways. This is what has led to the development of alternative workplace strategies." (Gibson, 2003, p18)*

The results indicate a mismatch between concentrated study office occupiers and their office layout, as evidenced by the negative 2.88 median result (Mawson, 2002). A possible solution, to improve the match between concentrated study workers and their office layout, would be to create an environment that includes “commons and caves” (Hurst, 1995; Steele, 1981). The balance for commons and caves would probably be more biased toward the caves, as concentrated study workers tend to undertake work on an individual basis. However, evidenced by the results, concentrated study workers perceive interaction as the most positive effect on their productivity and so there is a requirement for common areas that allow this interaction to take place, (Peterson & Beard, 2004). The adoption of common areas could also address the social isolation often identified by people that spend a large part of their time working away from the office environment (Downer, 2001).

The results for the concentrated study workers offer support for the hypothesis that it is the behavioural components of the office environment that have the greatest effect on productivity.

5.2.5 Transactional knowledge worker

The transactional knowledge worker category is defined as occupiers that spend more than 60% of their time with colleagues and have high – very high degree of flexibility to work where and how they wish. The demographic results for transactional knowledge workers can be seen in Table 5:5.

Table 5:5 Demographic results for transactional knowledge workers

		Transactional Knowledge Work
Type of Sector	Private Sector	22
	Public Sector	78
	Total	100
Type of Office	Cellular	20
	Open Plan	79
		1
	Total	100
Dedicated Desk	Yes	96
	No	2
		3
	Total	100
Gender	Male	53
	Female	44
		3
	Total	100
Age of Respondent	<25	5
	25-35	24
	36-45	34
	46-55	27
	>55	10
	Total	100
Time in the Office	0-20	2
	21-40	3
	41-60	22
	61-80	22
	81-100	50
	Total	100
Variety of tasks undertaken in the office	Very Low	
	Low	1
	Average	23
	High	53
	Very High	23
	Total	100
Overall Importance	Very Low	1
	Low	4
	Average	24
	High	51
	Very High	21
	Total	100

The age profile results for transactional knowledge workers follow a similar format to the other work pattern categories, with the majority of transactional knowledge workers being less than 45 years old (63%). This result gives support to the proposal that there is no relationship between the age of respondents and the type of work pattern they perform.

The gender profile is slightly biased towards the male population with 53% of respondents being male, and 44 % being female. This result, along with the other work pattern results, supports the proposal that a relationship could exist between the work pattern and the gender of the respondent.

The majority of transactional knowledge respondents report to work in open-plan office environments (79%). This result is similar to all the other work pattern results indicating that for all work patterns the open-plan environment is the dominant office type.

Whilst transactional knowledge workers perceive themselves to have a high – very high degree of flexibility to work where and how they wish, they do not appear to exercise this flexibility by working outside the office with 72% of reporting to spend more than 60% of their time in the office, and the modal category being 81-100% time in the office (50%).

The majority of transactional knowledge respondents report to be undertaking high to very high variety of tasks (76%), with the model category being high variety of tasks (53%). In comparison to the other work patterns the transactional knowledge respondents report to undertake the most variety of tasks. The results generally support the proposal that transactional knowledge workers are dynamic and interactive (Laing *et al,* 1998).

> *"The club office organization is for knowledge work: both highly autonomous and highly interactive. The pattern of occupancy is intermittent and over an extended working day." (Laing et al, 1998)*

However, only 2% of transactional knowledge worker respondents report to work at a non-dedicated desk, which is in contrast to the proposal that the office environment for transactional knowledge workers should be a mixture of shared settings (Laing *et al,* 1998).

"A variety of shared task based settings serve both concentrated individual and group interactive work." (Laing et al, 1998)

The results create a profile for the transactional knowledge worker. The profile being that they spend between 60%-100% of their time with colleagues, the majority spend between 60-100% of their time in the office and when in the office they undertake a high variety of tasks. The profile indicates that transactional knowledge workers work in a highly dynamic way.

Evaluative Variables

The relative distributions for each of the four components for the work pattern transactional knowledge work can be seen in Figure 5.5.

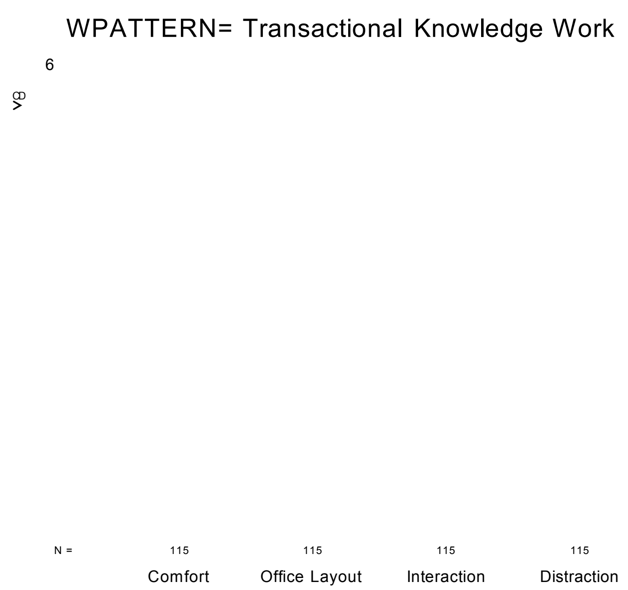

Figure 5.5 Box plots of evaluative variables for transactional knowledge work

The distributions for the comfort and office layout component have the same median value of 3.13, indicating a slight positively skewed response. These results are higher than any other work pattern, indicating that the transactional knowledge workers perceive their physical environment in more positive terms. It should also be noted that whilst transactional knowledge workers are defined as having flexibility in where they work, 72% report to spend between 61-100% of their time in the office. Therefore there is a clear indication that the office environment is where the transactional knowledge work takes place, as opposed to outside the office. This result places greater emphasis on the need for the design of an enabling environment (Stallworth & Klenier, 1996).

The interaction component has the highest median value (3.44) giving an indication of the value placed on interaction for transactional knowledge workers. The relatively high score of interaction can be understood, once one considers the process of transactional knowledge work. This work pattern is based on knowledge workers collaborating in a range of different groups or teams. The purpose is to transfer and create new knowledge, as knowledge creation can be considered as the output of a modern office environment (Clark *et al*, 2004).

The distraction component has the most negatively skewed distribution, with a median value of 2.67 and an upper quartile value of 3.33. This result demonstrates the tension that exists between interaction and distraction, (Heerwagen *et al*,, 2004). The transactional knowledge workers value interaction but see distraction as having a negative effect on their productivity. This creates a paradox, as one person's interaction is another person's distraction. To resolve this, consideration needs to be given to how transactional knowledge workers interact in the office, the type of office space provided, and the flow and dynamics of the office (Cornell, 2004).

The profile of the transactional knowledge worker has previously identified the dynamic nature of transactional knowledge work, and the requirement to act as part of a high performance team. This collaborative approach requires the office layout to consist of a range of shared settings (Laing *et al*, 1998). Becker & Steele (1995) support this approach, by suggesting that to identify the ingredients of a high performance workplace, consideration should be given to lessons that can be learned from the kindergarten classroom.

> *"The room is divided onto activity areas, each with its own distinct character. In one corner is a quiet reading area, with cushions and carpet, and kids absorbed in books, their bodies contorted into every conceivable position. In another corner, there is a sink and counter and linoleum floor; kids are making clay figures, laughing and chatting." (Becker & Steele, 1995, p3)*

The comparison of a kindergarten classroom and a high performance workplace may on the face of it appear strange. However, when consideration is given to the purpose of these environments, common elements emerge. Firstly, both environments have to be able to handle diversity of use, hence the requirement for different activity areas. Secondly both environments have to foster a collaborative approach to problem solving. And finally, both have the same overall purpose; that is to create and transfer knowledge (Ward & Holtham, 2000). Viewed in these terms, both schoolchildren and transactional knowledge workers have similar requirements of their working environments.

Achieving a multi-activity environment does not necessarily mean that there is a requirement for more space, since 96% of transactional knowledge workers have dedicated desks and 27% of transactional knowledge workers spend less than 60% of their time in the office there are opportunities for more flexible work patterns and more use of shared areas. The aim is not purely space reduction, but to have the right kind of space, thereby enabling an increase in productivity. Central to improving the office environment for transactional knowledge workers is the understanding of the social dynamic, the way that people interact with each other, and ensuring an environment is created to support those interactions (Nathan & Doyle, 2002). The matching of people to their office environment, with the aim of creating a high performance workplace, has been previously referred to as organisational ecology (Becker & Steel, 1995).

This people-centric approach to creating office environments also acknowledges that it is the empowered knowledge worker that is the "intellectual capital" of the organisation. Eltringham (1998) goes on to argue that it is the "*soft issues*" that keep people happy in their work, and the point is made that:

> *"Training, personal development, flexible hours, good working relationships and a pleasant environment are just are important as a fat pay cheque." (Eltringham, 1998, p24)*

It can be concluded that the results for transactional knowledge work support the hypothesis that it is the behavioural components of the office environment that have the greatest effect on productivity.

5.2.6 Summary

The results for the individual process workers reveal that the basics of environmental comfort and office layout do not appear to be met. It could be argued that since individual process work is location required and relatively static, people at the same desk for most of the day, then greater emphasis should be placed on the physical elements of the office environment. Individual process workers perceive that they have little flexibility in where they work, but since they spend a large percentage of their time working on their own, the question needs to be asked; do they actually need to be the office at all? Improvements in productivity could be achieved if consideration was given to individual process work being undertaken in the home environment (Wright, 2002). Allowing individual process workers to work more flexibly would require managers to be comfortable with not always being able to physically see their staff (Lupton & Haynes, 2000). This shift in emphasis from monitoring inputs, such as someone sat at their desk from 9.00am till 6.00pm, to an output based metric would allow a more enabling culture to develop (Turner and Myerson, 1998) Adopting such a strategy would have the added benefit of minimising distractions within the office. To ensure that productive interaction is maintained, consideration would need to be given to creating space, in the office environment, for this to occur, such as informal meeting areas and coffee bars (Peterson & Beard, 2004).

The nature of group process work means that people will be working collectively, as a team, on work processes. The results for group process workers highlight the benefits and disadvantages of this approach. Interaction is valued and receives the highest median value. However, distraction is perceived as having the most negative impact on the individual's productivity. Since group process workers are location required, so that they can work together as a team, flexible work strategies are not as appropriate. Therefore, greater emphasis is placed on the physical

(Leaman & Bordass, 2000; Oseland, 2004) and social dynamics, (Nathan & Doyle, 2002) of the office environment. An appropriate approach for group process workers could be to create project or themed areas, which indicate physically a group or team of people (Sims, 2000; Peterson & Beard, 2004). This has the benefit of allowing localised agreements with regards to layout and comfort systems. Adopting this approach could also lead to localised office protocols for working in a specific group or team, thereby addressing the interaction distraction issue (Brennan *et al*, 2002).

The concentrated study work pattern allows for a flexible workplace strategy with a large percentage of concentrated study respondents working outside the office environment. The concentrated study work pattern gives the respondent the opportunity to choose where they work, but when they are in the office environment they tend to work on their own. This type of work is sometimes referred to as individual knowledge work (Laing *et al*, 1997). It is therefore understandable why this work pattern perceives distraction as having the most negative effect on productivity. It should also be noted that whilst this group of respondents perceive themselves as individual workers, they do appear to value the component of interaction. Therefore, an appropriate environment, to increase the productivity for concentrated study respondents, would largely consist of individual areas, although consideration should be given to include some common areas, to ensure that the much-valued interaction takes place (Peterson & Beard, 2004). To ensure efficient use of space, both the individual and common spaces could be used on a shared basis. This approach has the advantage of providing the right kind of space, whilst at the same time reducing the demand for space. Since the concentrated study respondents have the flexibility to choose their workplace, they could use this flexibility to plan and book in advance individual space within the office. The common space could be used on a more ad hoc basis, thereby enabling more random interactions and conversations. An office designed on this basis would be similar to the combi-office, with the mixture of shared areas and an allocation of private individual space (van der Voordt, 2004).

The results from the transactional knowledge respondents indicate, evidenced by the relatively high utilisation of space, that the office environment is where transactional knowledge takes place. This work pattern reports the highest range of variety of tasks, coupled with a relatively high level of interaction with colleagues, indicating the dynamic nature in which this work pattern performs. Once again interaction is perceived as the major component that has a positive effect on perceived productivity, which is understandable as transactional knowledge workers output will be dependent on the quality of knowledge creation and transfer with other colleagues (Ward & Holtham, 2000; Clark *et al*, 2004). It is also understandable that distractions can be a consequence of having a highly dynamic and interactive workplace, and it is clear that strategies need to be introduced to reduce their negative effect on productivity. One such strategy could include the development of office protocols (Brennan *et al*, 2002). The physical layout and the comfort of the office should be designed to accommodate the diversity of use. This could be achieved by considering "multi-activity" areas (Becker & Steel, 1995).

This section of analysis has evaluated each of the work patterns in terms of demographic profile and evaluative results. The evaluative results have been interpreted in the context of the work pattern under analysis, thereby revealing a more meaningful appreciation for the effects on productivity in the office environment.

The purpose of this section of analysis was to analyse the results for the specific work patterns (Laing *et al*, 1998) and establish meaning and relationships. In all of the four work patterns evaluated it was found that interaction was perceived to be the component to have the most positive effect on productivity and distraction was perceived to have the most negative. It is therefore concluded that the results in this section have provided support for the hypothesis that it is the behavioural components of the office environment that have the greatest effect on office productivity.

The next section of analysis will use the four components of office layout, comfort, interaction and distraction as the common metrics of analysis, thereby enabling statistical difference tests to be undertaken between work patterns.

5.3 Confirmatory work pattern data analysis

5.3.1 Introduction

This section aims to establish if there are any statistically significant results in both the categorical and evaluative results for the various work patterns. The first part of the analysis uses Chi-squared analysis to establish if any statistical associations exist between the demographic data and the work patterns. The second part of the analysis uses ANOVA techniques to establish if any statistically significant differences exist for each of the evaluative components and the different work patterns.

Ultimately, this section aims to evaluate hypothesis three, by establishing if there are any statistically significant differences between the work patterns and their assessment of office productivity.

Hypothesis Three:

There is no significant difference between work patterns in terms of office productivity.

The final hypothesis aims to establish if office occupiers, who adopt different work patterns, can be segmented based on differences of perceived productivity with regards to the physical environment and the behavioural environment.

5.3.2 Work pattern demographics

This section aims to explore the relationships between the different category variables and the work pattern subsets, to establish associations and statistical significance. The results of the Chi-squared analysis can be seen in Table 5:6.

Table 5:6 Chi-squared analyses of work patterns and categorical variables

		Individual Process Work	Group Process Work	Concentrated Study Work	Transactional Knowledge Work	Total	Chi-Square Test
Type of Sector	Private Sector	31	31	28	22	30	
	Public Sector	69	69	72	78	70	4.27, df 3, ns
	Total	100	100	100	100	100	
Type of Office	Cellular	16	18	23	20	18	
	Open Plan	83	81	76	79	81	7.70, df 6, ns
		1	1	1	1	1	
	Total	100	100	100	100	100	
Dedicated Desk	Yes	96	97	91	96	95	
	No	4	2	8	2	4	21.6, df 6, p<0.01
		1	0	1	3	1	
	Total	100	100	100	100	100	
Gender	Male	44	33	61	53	44	
	Female	54	66	38	44	54	56, df 6, p<0.01
		2	1	1	3	2	
	Total	100	100	100	100	100	
Age of Respondent	<25	5	5	4	5	5	
	25-35	32	30	30	24	30	7.157, df 12, ns
	36-45	31	29	30	34	30	
	46-55	25	30	28	27	27	
	>55	7	6	8	10	7	
	Total	100	100	100	100	100	
Time in the Office	0-20	1	0	3	2	1	
	21-40	7	3	15	3	7	221.2, df 12, p<0.01
	41-60	16	4	32	22	16	
	61-80	16	13	25	22	17	
	81-100	59	80	25	50	59	
	Total	100	100	100	100	100	
Variety of tasks undertaken in the office	Very Low	2	3	1		2	
	Low	9	4	4	1	6	78.27, df 12 p<0.01
	Average	48	47	40	23	44	
	High	32	33	45	53	37	
	Very High	8	14	10	23	12	
	Total	100	100	100	100	100	
Overall Importance	Very Low	1	1	0	1	1	
	Low	2	4	4	4	3	16.7, df 12, ns
	Average	19	18	24	24	20	
	High	52	47	51	51	50	
	Very High	25	30	21	21	26	
	Total	100	100	100	100	100	

The Chi-squared results in Table 5:6 indicate that there are no statistical associations between the work patterns and the following categories: Type of sector, type of office, age of respondent and overall assessment of importance of office environment.

The remaining results (Table 5:6) indicate that statistical associations exist and will now be discussed further.

Analysis of the gender of respondents and their work pattern reveals that an association exists with more females undertaking group process work, and more males undertaking concentrated study work (56, df 6, p<0.01).

There appears to be a significant association between dedicated desk and the different work patterns (21.6,df 6,p<0.01). Further analysis indicates that the main under and over occurrences appear in the group process and concentrated study patterns. The group process results indicate more dedicated desks and less non-dedicated desks than expected. The concentrated study results indicate less dedicated desks and more non-dedicated desks than expected. These results support the work pattern model for flexible working, with non-dedicated desks for concentrated study work, and dedicated desk for group process work (Laing *et al*, 1998). Further support is found in the time spent in the office results, with the main under and over occurrence appearing in the group process and concentrated study work patterns. The group process results show an under occurrences of between 0-80% time spent in the office, and an over occurrence of between 80-100% time spent in the office, indicating a location required job type. Conversely the concentrated study results show an over occurrences of between 0-80% time spent in the office, and an under occurrence of between 80-100% time spent in the office, indicating a more flexible approach to working (221.2, df 12, $p<0.01$), (Laing *et al*, 1998).

Analysis of variety of task and work processes reveals that the main under and over occurrences appear in the individual and transactional knowledge work patterns. The individual processes reporting less than expected high-very high variety of tasks, and more than expected very low - average variety of tasks. Conversely the transactional knowledge respondents reporting an over occurrence of high -very high variety of task and an under occurrence of very low – average variety of tasks undertaken when in the office environment (78.27, df 12, $p<0.01$). These results support the notion that individual process workers undertake a range of simple repetitive tasks.

> *"Work is broken down into the smallest components and carried out by staff who are given precise instruction and little discretion." (Laing* et al*, 1998, p27)*

Additionally, the results also support the proposal that transactional knowledge workers are constantly engaged in a range of different types of tasks.

> *"High-level work carried out by talented independent individuals who need to work both collaboratively and individually: the work process is constantly being re-designed." (Laing* et al*, 1998, p27)*

The overall importance result was included in the questionnaire as a way of validating the research stance of offices affecting productivity. It asked respondents to rank in level of importance the effects the office environment had on their productivity relative to all other components that could effect their productivity. The Chi-square test reveals that there is no association between the work pattern and the measurement of overall importance (16.7, df 12, ns). This could be interpreted as meaning that when it comes to assessing the level of overall importance there is no differentiation between work patterns, i.e. all work patterns reporting similar results. Therefore using the total results it can be seen that 50% of respondents report the office environment to be of high importance, and 26% of respondents report that the office environment is of very high importance with regards to the affect on their productivity.

5.3.3 Summary of work pattern demographics

The Chi-squared analysis of the categorical variables reveals that there is no association between the type of sector and the work patterns, both private and public sector produce similar profiles of the different work pattern categories. Likewise there appears to be no link between the age of the respondent, and the type of work pattern they undertake.

The gender results indicate that more females undertake group process work than males, and more males undertake concentrated study work than females.

The results for the type of office show that 81% of the total respondents work in open-plan office, and no statistical association exists between the type of office and the work pattern undertaken. This result indicates that the majority of respondents in all work patterns work in open-plan environments.

The dedicated desk results and the time spent in the office results support the notion that group process workers are relatively more location required, and the concentrated study workers are relatively more flexible in the time they spend in the office environment (Laing *et al*, 1998).

The variety of task results support the proposal that individual process workers undertake repetitive tasks with little variation in the type of work (Laing *et al*, 1998). Conversely, the transactional knowledge results support the proposal that these office occupiers undertake a range of different activities when in the office environment (Laing *et al*, 1998).

The overall importance results reveals that 76% of respondents believe that when it comes to the affects on their productivity, the office environment has a high-very high level of importance.

The next section will use ANOVA techniques to establish if any statistically significant differences exist for each of the evaluative components and the different work patterns.

5.3.4 Work pattern ANOVA

This section of analysis aims to evaluate the four components to establish consistency of results across the four work patterns. The section will start with ANOVA results to establish significant differences between the components and the work pattern categories. Subsequently each of the four component results will be analysed to ascertain which of the work pattern categories results are significantly different.

ANOVA Results

The ANOVA results (Table 5:7) indicate that there are highly significant differences within the responses for comfort ($F\ (3,1389) = 7.377$, $p<0.01$), office layout ($F\ (3,1392) = 8.005$, $p<0.01$), interaction ($F\ (3,1391) = 7.801$, $p<0.01$), distraction ($F\ (3,1389) = 5.763$, $p<0.01$).

Table 5:7 Work pattern ANOVA results

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Comfort	Between Groups	14.789	3	4.930	7.377	.000
	Within Groups	928.172	1389	.668		
	Total	942.961	1392			
Office Layout	Between Groups	16.203	3	5.401	8.005	.000
	Within Groups	939.192	1392	.675		
	Total	955.395	1395			
Interaction	Between Groups	12.512	3	4.171	7.801	.000
	Within Groups	743.662	1391	.535		
	Total	756.174	1394			
Distraction	Between Groups	12.892	3	4.297	5.763	.001
	Within Groups	1035.663	1389	.746		
	Total	1048.555	1392			

Since the Levene statistic, as can be seen in Table 5:8, for office layout and interaction were $p>0.05$ the Tukey HSD statistic was used. However since the Levene statistic for the components of comfort and distraction were $p<0.05$, Games-Howell statistic was used (Field, 2000).

Table 5:8 Levene statistics for four office components

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Comfort	9.385	3	1389	.000
Office Layout	2.493	3	1392	.059
Interaction	2.477	3	1391	.060
Distraction	2.808	3	1389	.038

Having established that statistical significant differences exist between the four components and the work patterns, the next part of the analysis will evaluate each of the components in turn, to identify which of the work patterns are significantly different and offer an accompanying interpretation of the results.

Comfort

The comfort component can be seen as containing two elements of comfort, those being "hard" and "soft". The hard variables relate to the traditional environmental comfort variables of heating, lighting and ventilation, whilst the soft variables relate to the décor and cleanliness of the office environment, and also the physical security of the office occupier.

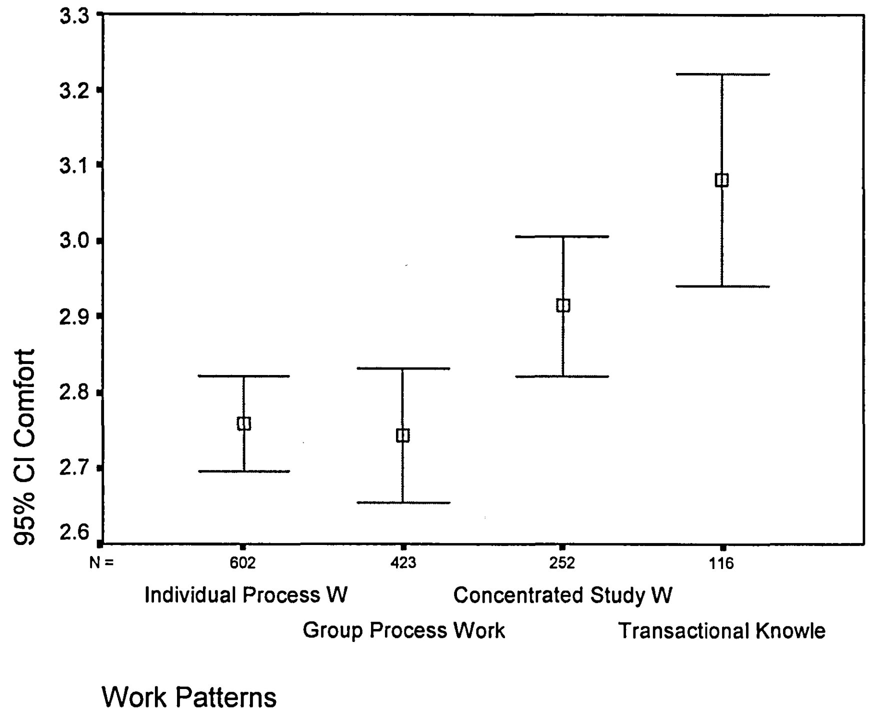

Figure 5.6 Error bars for comfort and work patterns

The comfort results (Figure 5.6) indicate that the only group to perceive comfort as having a positive effect on their productivity were the transactional knowledge workers (transactional knowledge work = 3.08). Whilst the group that report comfort to be having the most negative effect on their productivity are the group process workers (group process work = 2.74).

Table 5:9 95% confidence interval results for comfort and work patterns

		N	Mean	95% C.I. of Mean	
				Lower Bound	Upper Bound
Comfort	Individual Process Work[1]	602	2.76	2.70	2.82
	Group Process Work[2]	423	2.74	2.65	2.83
	Concentrated Study Work[1,2]	252	2.91	2.82	3.01
	Transactional Knowledge Work[1,2]	116	3.08	2.94	3.22
	Total	1393	2.81	2.77	2.85

The results in Table 5:9 indicate that there are two highly significant different groupings (individual process work = 2.76, concentrated study = 2.92, transactional knowledge work = 3.08, $p<0.01$) and (group process work = 2.74, concentrated study = 2.91, transactional knowledge work = 3.08, $p<0.01$).

The result indicate that no statistical difference exists between concentrated study and transactional knowledge respondents indicating that these two work patterns share the same view when it comes to office comfort. An explanation for this finding could be that both the concentrated study workers and transactional knowledge workers have the flexibility to work anywhere, any time. This means that if they feel uncomfortable in the office environment they can work away from the office setting, or even somewhere else in the office environment. This effectively gives the individual an element of control of their comfort in the office environment (Whitely *et al*, 1995; Whitley *et al*, 1996).

In contrast, the individual process and group process workers have no autonomy in where they work, as they are location required. It could be argued that for these groups of workers there is a higher demand of the comfort systems, as they are in the office for most of the time. This is supported by the results for the time spent in the office, with 93% of the group process workers reporting that they spend more than 60 % of their time in the office, and 76% of the individual process workers reporting that they spend more than 60 % of their time in the office.

It is worth noting that it is the group process workers who report the most negative result for the comfort of the office environment. This could be caused by the fact that not only are these workers desk bound, but they also work in groups and therefore any alteration to the comfort systems would have to be agreed on a team basis. This clearly has the possibility of conflict and ultimately compromise. This finding supports one of the conclusions of the NEW study (Laing *et al*, 1998).

> *"The key issue for den organisations (group process workers) is how to enable group consensus based decisions." (Laing et al, 1998, p10)*

These results support the notion of *"locus of control"*, that is a linkage between individuals' perceived productivity and perceived control of the office comfort systems (Whitely *et al*, 1995; Whitley *et al*, 1996).

The statistical results show that at best the environmental comfort systems are having a neutral effect on productivity for transactional knowledge workers and concentrated study workers, and at worst they are having a negative effect on the individual process and group process workers. These results demonstrate that there is a clear need for improved comfort systems for the individual and group process workers. These results are partly supported by the NEW results (Laing *et al*, 1998).

> *"Existing environmental systems meet the relatively simple requirements of the hive (individual process workers) and the cell office (concentrated study workers) more easily than those of the more complex patterns of the den (group process workers) and the club (transactional knowledge workers)." (Laing et al, 1998, p8)*

However, in contrast to the NEW results, the negative results for individual process indicate that it is inappropriate to consider the individual process workers' requirements for comfort systems to be "relatively simple".

The results also show that there are significantly different groups, and therefore there are differing requirements for the comfort systems depending on the work pattern. The implication of this finding is that when designing offices of mixed work patterns, specific attention needs to be paid to range of demands placed on the comfort systems. This result is supported by the NEW results.

> *"Environmental systems should provide a higher degree of control, both for individuals and groups, than is available at present." (Laing et al, 1998, p10)*

Office Layout

This component relates to office workers on different levels. The first level relates directly to the individual, such as their workarea, personal storage and the feeling of privacy in an office environment. The second level relates more to the wider office concept, such as general storage and facilities to undertake work away from the desk, such as formal, informal and quiet areas. The office layout is linked to the flow of the office, which is accounted for in the circulation space.

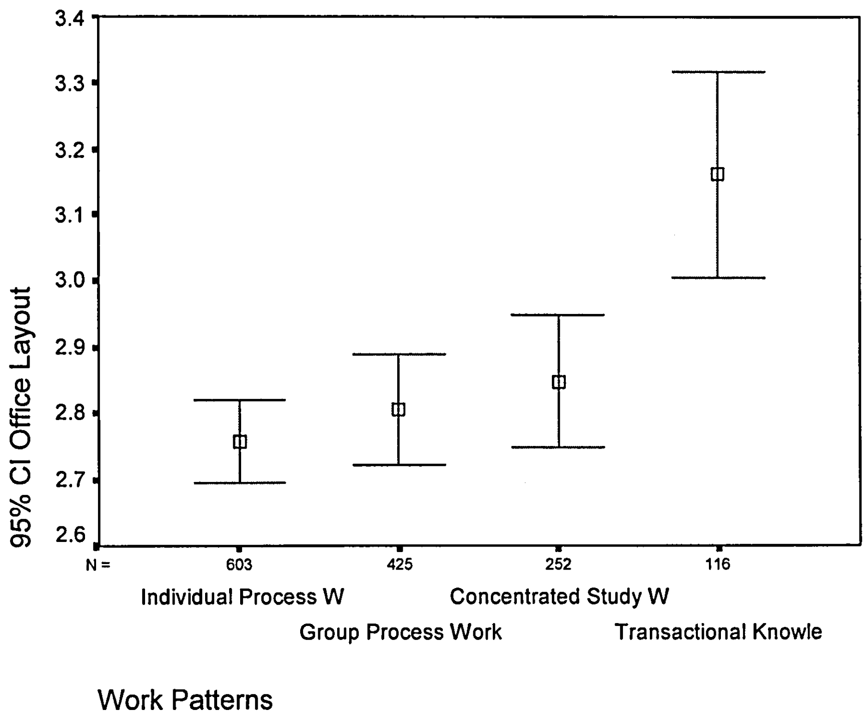

Figure 5.7 Error bars for office layout and work patterns

The results in Figure 5.7 graphically demonstrate the range of confidence intervals for office layout and work patterns. Clearly, transactional knowledge workers have the most positive mean score and the largest confidence interval. In contrast the individual process workers have the most negative mean score and the smallest confidence interval.

Table 5:10 95% confidence interval results for office layout and work patterns

		N	Mean	95% C.I. of Mean	
				Lower Bound	Upper Bound
Office Layout	Individual Process Work	603	2.76	2.69	2.82
	Group Process Work	425	2.80	2.72	2.89
	Concentrated Study Work	252	2.85	2.75	2.95
	Transactional Knowledge Work*	116	3.16	3.00	3.32
	Total	1396	2.82	2.78	2.86

The results in Table 5:10 show that for the component of office layout, the transactional knowledge workers' results are positive and are significantly different from the other groups (individual process work = 2.76, group process work = 2.8, concentrated study = 2.85, transactional knowledge work = 3.16 $p<0.01$).

The transactional knowledge workers define themselves as highly interactive with colleagues when in the office environment, and have the flexibility to work anywhere any place and any time. Whilst the transactional knowledge workers have the flexibility to work outside of the office, further analysis reveals that 72% of them spend more than 60 % of their time in the office. Therefore it could be concluded that they perceive that they are working flexibly within the office environment although not tied to a particular part of the office. This result indicates the dynamic nature of the transactional knowledge workers. This is supported by the result which shows that when in the office 76% of the transactional knowledge workers report to be undertaking high-very high variety of tasks. The results support the pattern of working proposed by the NEW research (Laing *et al*, 1998).

The concentrated study workers report to have the same degree of flexibility as the transactional knowledge workers, and also act on that flexibility with 50% of the respondents spending less than 60 % of their time in the office, but clearly feel that the office layout is having a negative impact on their productivity. Laing *et al* (1998) define concentrated study work as:

> *"High-level work carried out by talented independent individuals (isolated knowledge worker)." (Laing* et al*, 1998, p27)*

Investigating the type of office that concentrated study workers report to be working in reveals that 23% work in cellular and 76% work in open-plan. Also 91% report to have a dedicated desk whilst 8% report to have no dedicated desk. These results appear to be in contrast to the proposed type of space layout by the NEW research.

> *"Highly cellular enclosed offices or individually used open workstations with high screening or partitions." (Laing* et al, *1998, p27)*

Whilst it is not a natural conclusion that all concentrated study workers have to have cellular offices, as the same type of environment can be created in an open-plan, it is clear that the right types of environments are not being created. Also with 50% of concentrated study workers reporting that they are in the office less than 60% of the time and only 8% reporting to not have a dedicated desk, there is clearly an opportunity to consider more shared use of desks. This would release space so that the right kind of space, i.e. more cellular type space, can be created. This approach would enable more efficient use of space with less space per person and the right kind of space (Peterson & Beard, 2004).

The groups that report office layout to be having the most negative effect on their productivity are the individual process workers and the group process workers. Both groups share the common element of perceiving that they have very low – average degree of flexibility on how and where they work. Also both groups report a certain amount of repetition in their work with 60% of individual process workers and 53% of group process workers reporting very low – average variety of tasks undertaken in the office environment. As previously identified with the comfort component, where office workers are more desk bound when in the office, there is more of an emphasis on providing the appropriate office layout solution.

Clearly the results for office layout indicate that only the transactional knowledge workers perceive the layout to be having a positive effect on their productivity, and the remaining work patterns perceive the office layout to be having a negative effect on their productivity. Duffy (2000) proposes that office design has not developed as far as was promised as in the early 1990s. The results presented for office layout support this point, and indicate that the situation may be worse than Duffy (2000) believes, with three of the four work patterns reporting a negative effect on their productivity. One observation, from the results, is that if office environments are disabling productivity, then part of the solution may be to review the design process and ensure that occupiers are consulted at an earlier stage (Burke & Chidambaram, 1999).

Designing office environments from the occupier perspective has a number of advantages (Laframboise *et al*, 2003):

1. It establishes occupier ownership and commitment to the solution.

2. It allows the space planners a better understanding of how the occupiers use of space.

3. It offers a vehicle for managing change and occupier expectations

Interaction

This component is defined by the ability of office workers to interact on both a work level and a social level (Nathan & Doyle, 2002). This component is closely linked to office layout as this can be seen as an enabler of interaction with the positioning of colleagues, equipment and refreshments. On another level, there is the ability to interact with the space within the office; the atmosphere and the creativity within the office environment allow this to be captured (Stokols *et al*, 2002).

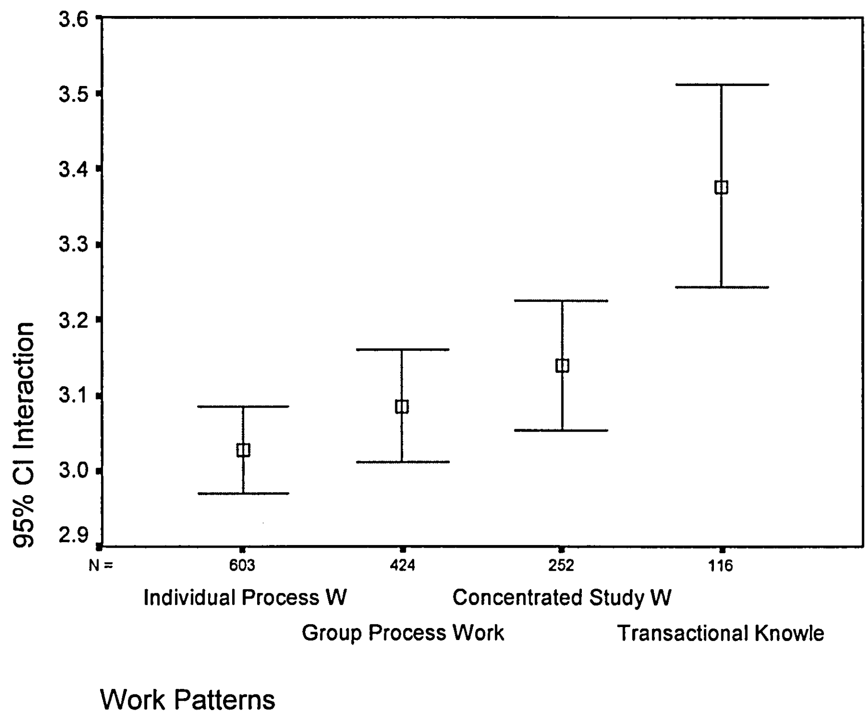

Figure 5.8 Error bars for interaction and work patterns

The results in Figure 5.8 graphically demonstrate the range of confidence intervals for interaction and work patterns. Clearly, transactional knowledge workers have the most positive mean score and the largest confidence interval. In contrast the individual process workers have the least positive mean score and the smallest confidence interval. All work patterns reported that interaction in the office environment was perceived as having a positive effect on their productivity. This finding is significant, as it demonstrates that whilst the work patterns individual process work and concentrated study work spend less that 60% of their time working with colleagues in the office environment, the time they do spend with colleagues is valued.

Table 5:11 95% confidence interval results for interaction and work patterns

		N	Mean	95% C.I. of Mean	
				Lower Bound	Upper Bound
Interaction	Individual Process Work	603	3.03	2.97	3.08
	Group Process Work	424	3.09	3.01	3.16
	Concentrated Study Work	252	3.14	3.05	3.23
	Transactional Knowledge Work*	116	3.38	3.24	3.51
	Total	1395	3.09	3.06	3.13

As can be seen in Table 5:11 a significant difference exists between the transactional knowledge workers and the other work pattern categories (individual process work = 3.02, group process work = 3.1, concentrated study = 3.1, transactional knowledge work = 3.4 $p<0.01$). The group that report office layout to be having the least positive effect on their productivity are the individual process workers.

The results show that all groupings value the concept of interaction, although in varying degrees. It is worth noting that the two groups that report the most positive results are the transactional knowledge workers and the concentrated study workers, both have in common the idea of knowledge work, with the former being group knowledge work and the latter being individual knowledge work. Whilst the results are positive for the process workers, both individual and group, they are clearly not as positive as both the knowledge worker groups.

These results illustrate the concept of "*social dynamics*" (Nathan & Doyle, 2002), and make the point that if offices are to be designed for maximum productivity then the dynamic nature of interaction needs to be integrated into the design of office environments. The interaction results support the proposals that the modern office environment needs to enable and encourage interaction, thereby facilitating knowledge exchange (Ward & Holtham, 2000).

Distraction

This component contains the variables that can disrupt an office environment by creating disablers to productive work (Mawson, 2002). Distraction is a function of the office layout, and is a composite of the amount of noise generated in the office, and the number of interruptions received in a working day.

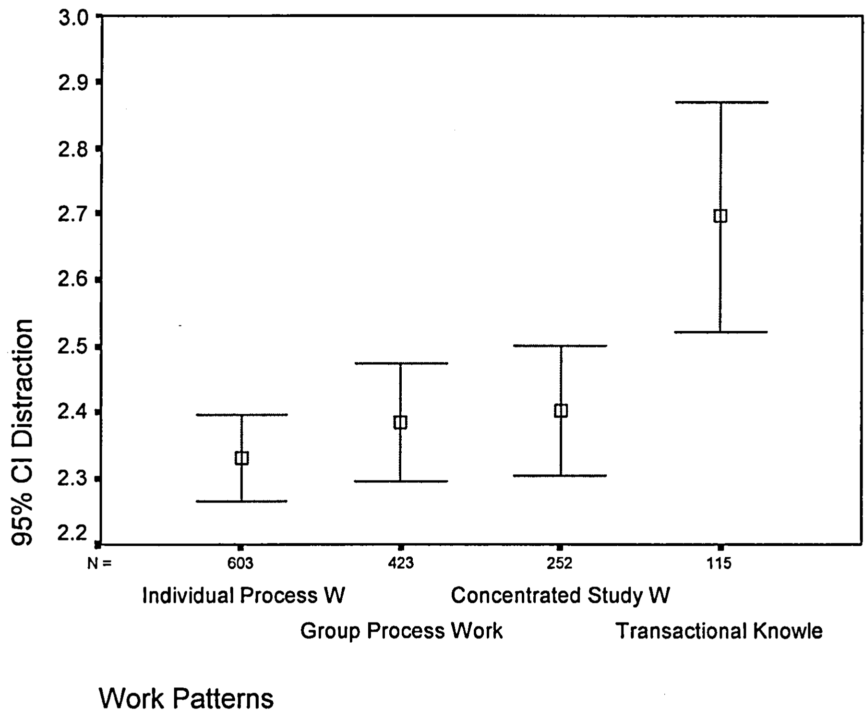

Figure 5.9 Error bars for distraction and work patterns

The results in Figure 5.9 graphically demonstrate the range of confidence intervals for distraction and work patterns. Clearly, as in the previous components, transactional knowledge workers have the most positive mean score and the largest confidence interval. In contrast the individual process workers have the most negative mean score and the smallest confidence interval. In contrast to the findings of Olson (2002), this study measures the component distraction using a multi-item scale; in addition this study provides a brake down of analysis by work pattern type (Laing *et al*, 1998). It can be seen in Figure 5.9 that all categories of work patterns reported distraction in the office environment to be having a negative effect on their productivity.

Table 5:12 95% Confidence interval results for distraction and work patterns

		N	Mean	95% C.I. of Mean	
				Lower Bound	Upper Bound
Distraction	Individual Process Work	603	2.33	2.26	2.40
	Group Process Work	423	2.38	2.30	2.47
	Concentrated Study Work	252	2.40	2.31	2.50
	Transactional Knowledge Work*	115	2.70	2.52	2.87
	Total	1393	2.39	2.34	2.44

As can be seen in Table 5:12 a highly significant difference exists between the transactional knowledge workers and the other work pattern categories (individual process work = 2.33, group process work = 2.38, concentrated study = 2.4, transactional knowledge work = 2.7 $p<0.01$). The group that report office layout to be having the most negative effect on their productivity are the individual process workers.

Whilst all categories report a negative result, the transactional knowledge worker reports the least negative. This could be because, as established previously, the transactional knowledge worker has the flexibility to work in different parts of the office and is therefore not restricted to a particular desk. Olson (2002) identified that on average people spend 35% of their time making noise near other people's desk. In addition, the nature of transactional knowledge work involves interaction, and therefore transactional knowledge workers could be more tolerant of distractions, such as interruptions. This is clearly a balancing act, as one person's interruption is another person's interaction (Heerwagen *et al*, 2004: Haynes & Price, 2004)

Further analysis of the variety of tasks undertaken indicates a relationship between distraction and variety of tasks.

Table 5:13 Variety of tasks and work patterns

	Individual Process	Group Process	Concentrated Study	Transactional Knowledge
High - Very High Variety of Tasks	41%	47%	55%	76%
Mean Response	2.33	2.38	2.4	2.7

The results presented in Table 5:13 indicate that the more variety of tasks undertaken in the office environment, the less distractions are seen as having a negative effect on productivity. The extremes of the variety of task results support the NEW model (Laing *et al*, 1998) with the individual process workers undertaking mainly very low to average variety of tasks (60%), and transactional knowledge workers undertaking high to very high variety of tasks (76%). There appears to be evidence to support the proposal that workers that undertake high to very high variety of tasks in the office, whilst perceiving distractions to be negative, are less susceptible to distractions than office workers who undertake very low to average variety of tasks. The results indicate that productivity improvements could be achieved by the creation of a distraction free working environment (Mawson, 2002; Cornell, 2004).

5.3.5 Summary of work pattern ANOVA

Results for the comfort component reported no significant difference between the concentrated study and the transactional knowledge workers. However, significant differences did exist between the process worker groupings, individual and group, and the knowledge worker groupings, individual and group. A possible explanation for this result could be that concentrated study and transactional knowledge workers have more flexibility in where they work, therefore they can exercise more control over their environmental comfort by moving around the office (Whitely *et al*, 1995; Whitley *et al*, 1996). In contrast individual and group process workers are location required and therefore place a higher demand on the comfort systems (Laing *et al*, 1998).

The results for office layout indicate that only transactional knowledge workers perceive their office layout to be having a positive effect on their productivity. All the other work pattern categories perceive office layout to be having a negative impact on their productivity. This result on its own has a large implication, as it indicates that office environments are been designed without a detailed appreciation of the occupiers' proposed use of space (Peterson & Beard, 2004). An opportunity exists to ensure that office occupiers are consulted at all stages of the design process to ensure that the optimum office layout is achieved (Burke & Chidambaram, 1999; Laframboise *et al*, 2003).

All the work pattern categories reported a positive result for the component interaction, indicating it's perceived value on productivity, although the transactional knowledge workers result was statistically significantly different from any of the other work pattern categories. This result illustrates the perceived value of interaction for transactional knowledge workers, supporting the proposition knowledge exchange is vital ingredient of the modern office (Ward & Holtham, 2000). It should also be acknowledged that individual process workers, who are traditionally considered to be process production units (Laing *et al*, 1998), also perceive interaction as having a positive effect on their productivity. The interaction results clearly illustrate that the social dynamics of the office environment should be considered for all work patterns (Nathan & Doyle, 2002).

All work pattern categories reported a negative result for the component of distraction (Olson, 2002; Mawson, 2002; Cornell, 2004). This result clearly indicates a common issue for all the work pattern categories. The transactional knowledge workers perceived distraction least negatively of all the other work pattern groups, which could be interpreted as indicating they are more tolerant of distractions. The results also indicated that the higher the varieties of tasks undertaken in the office, the least negative the results for distraction.

Overall, transactional knowledge workers reported more positive results than any of the other work pattern categories and were consistently a statistically significant different grouping from the other work patterns. Generally, there were no statistically significant differences in the results for individual process workers, group process workers and concentrated study workers for the components office layout, distraction and interaction. These results indicate, for these components, that the work patterns share the same view.

The two components that generally received consistent results were interaction and distraction. All the interaction results reported were positive, indicating a consensus across all the work pattern categories. Likewise all the distraction results reported were negative, indicating the consensus of opinion. These results indicate the perceived benefit of interaction in the office environment (Becker & Sims, 2001;

Heerwagen *et al*, 2004) but also highlight the potential disadvantages of distraction (Olson, 2002; Mawson, 2002; Cornell, 2004).

5.4 Conclusion

This chapter has used the components; office layout, comfort, interaction and distraction as redefined evaluative variables. The four components were used as a basis of analysis so that comparison between work patterns could be made. The first analysis aimed to evaluate hypothesis two:

> *Hypothesis Two:*
>
> *It is the behavioural components of office productivity that have a greater effect on productivity than the physical components.*

In each of the four work patterns a comparative analysis of the four office productivity components provided supporting evidence for hypothesis two. This finding demonstrates that it is the behavioural components of interaction and distraction that have the greatest impact on perceived productivity. Clearly the results indicate the importance of the occupier perspective in establishing a productive office (Fleming, 2004). This finding also supports the proposal that the office environment consists of social dynamics (Nathan & Doyle, 2002) and the results indicate that social dynamics are present in all four work patterns evaluated.

The second analysis undertaken aimed to evaluate hypothesis three:

> *Hypothesis Three:*
>
> *There is no significant difference between work patterns in terms of office productivity.*

Evaluation of the four office productivity components established that statistically significant differences existed between some of the different work patterns. On this basis hypothesis three would have to be rejected and therefore the possibility of segmentation based on work patterns exists.

The results of the components office layout, distraction and interaction illustrated that no statistically significant difference exists between individual process workers, group process workers and concentrated study workers. However, a statistically significant difference did exist for the transactional knowledge workers. Evaluation of the component comfort identified two distinct groups those being knowledge workers and process workers.

These results demonstrate that if a better match between office occupiers and their office environments is to be achieved (Mawson, 2002), greater consideration needs to be given to the different work patterns adopted, especially the transactional knowledge work pattern.

6 Conclusions

6.1 Introduction

The literature review presented in Chapter 2 established that research investigating the effects of the working environment on its occupants' productivity could be traced back to the 1930s. One of the fundamental conclusions of these studies was the acknowledgment that the social dimension played an important role and was an integral part of the work environment. Whilst this discovery was made over 75 years ago, little research has been undertaken to further develop an understanding of the social concept, especially in the office environment. It is only recently that the literature has started to debate the behavioural components of the office environment, with a growing acceptance that they may have an impact on office occupier productivity.

The literature review established the difficulty that previous researchers have had in defining what constitutes office productivity. There appears to be no universally accepted definition of productivity of office occupiers, let alone any agreed way of measuring office occupiers' productivity. Productivity measures, in a manufacturing context, simply relate outputs to inputs[34]. Since the outputs from office occupiers can be more varied, the problem of measuring productivity becomes compounded. The varied range of outputs of office occupiers can be attributed to the range of different types of work undertaken in the office environment, with an increasing emphasis being placed on knowledge work.

Previous research into the relationship between the office environment and its occupants' productivity has tended to be conducted across two main discipline areas, those of facilities management, specifically workplace, and environmental psychology. However, later research appears to be suggesting that a collapsing of these boundaries is starting to emerge.

The main body of literature that attempts to link office environments and productivity largely addresses the physical environment. Whilst there appears to be no universally accepted means of measuring office productivity, there does appear

[34] It could be argued that this is one of the largest issues facing facilities management measurement systems.

to be acceptance that a self-assessed measure of productivity is better then no measure of productivity (Whitley, 1996; Oseland, 1999 and 2004; Leaman and Bordass, 2000).

The attempts made to link the physical environment with the productivity of its occupant's falls into two main categories: those of office layout and office comfort. The literature relating to the office layout appears to revolve around two main debates: those of open-plan verses cellular offices, and the matching of the office environment to the work processes. It could be argued that the open-plan debate has led to cost reduction, as the prevailing paradigm with regards to office environments. Also, matching office environments to work processes requires a greater understanding of what people actually do when in the office environment, which is still a subject of much debate. It must be noted that much of the physical environment literature reviewed lacked any theoretical framework, and where empirical evidence was provided the sample sizes tended to be relatively small: Leaman and Bordass (2000) and Oseland (2004) being notable exceptions.

Research that attempts to address the behavioural environment tends to be at the theoretical and anecdotal stage, with little supporting empirical evidence, a notable exception being Olson (2002). However, there appears to be a growing awareness of the impact of the behavioural environment on occupants' productivity. Established in the literature review is the potential tension that can exist in the office environment between individual work and group work. If the office environment is to act as a conduit for knowledge creation, and knowledge transfer, then offices need to allow both collaborative work and individual work to coexist without causing conflict between the two.

The main objective of the literature review was to establish the gaps in the existing knowledge relating office environments and office occupiers' productivity. The main conclusions drawn for the literature review can be summarised as follows. Firstly, whilst interest in the environment and productivity can be traced back to the 1930s, there has been little development of these earlier concepts, and notably very little empirical research. Furthermore, the empirical research that has been undertaken tends to be concerned with the physical environment, notably layout and comfort. Secondly, whilst there is increasing debate about the effects on office occupants' productivity of the behavioural environment, it is still an area that is in is infancy with regards to research evidence.

The overall aim of this research was to develop a validated theoretical framework for the evaluation of office productivity that will include the physical and behavioural environment, and also accommodate the different work processes of office occupiers. The research broadens the understanding of the office environment from that of a purely physical environment to include the behavioural environment. This provides an insight into the dynamic nature, or connectivity, of office environments. The main objective of this thesis was to investigate the effects of the office environment on its occupants' perceived productivity.

The remainder of this chapter will be structured as follows. Firstly, the principal findings and conclusions will be presented. The findings will predominately be drawn from the methodology chapter (Chapter 3), the model development chapter (Chapter 4) and discussion of results chapter (Chapter 5). Secondly, how the study has contributed to the main body of knowledge will be presented. Thirdly, the limitations of the study will be clearly established. Fourthly, areas for further research will be identified. Finally, the chapter will conclude with my reflections on the research process.

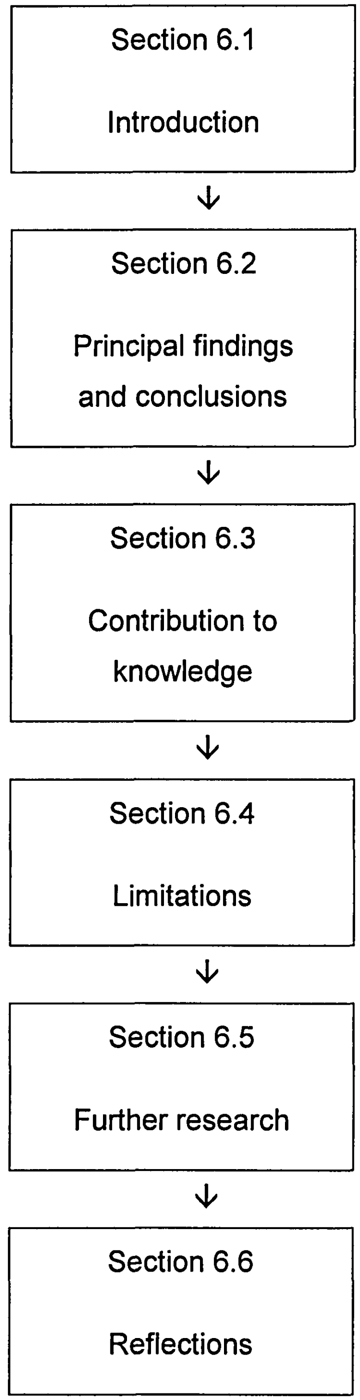

Figure 6.1: Structure of Chapter 6

6.2 Principal findings and conclusions

6.2.1 Evaluation of Office Productivity

One of the main objectives of this study was to establish a theoretical framework to measure office productivity. The theoretical framework developed contained the main dimensions of physical environment and behavioural environment. Since it has been established that little evidence exists that links the behavioural environment to the office occupiers' productivity, it was essential that this be included in the theoretical framework. The physical environment dimension was included since some evidence exists, in the literature, to support this dimension, specifically office layout and office comfort, and it also provided an opportunity to make comparisons. Added to these was the additional dimension of work pattern, which allows for categorisation of workers by the way they undertake their work. The theoretical framework developed can be seen in Figure 6.2.

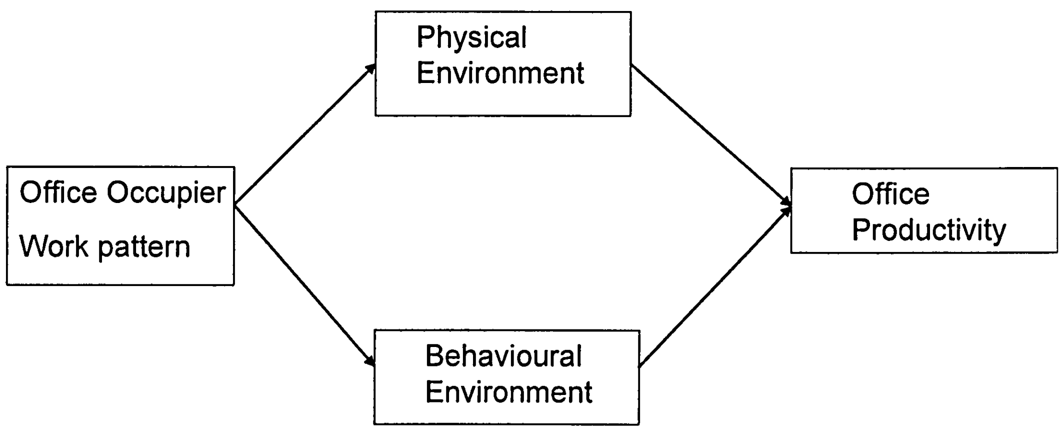

Figure 6.2 Theoretical framework of office productivity

The creation of the theoretical framework allowed the formation of three testable propositions. The principal findings and conclusions for each of the hypothesis tested will be presented in the following sections.

6.2.2 Model development for office productivity

Hypothesis One: Office productivity is a composite of the physical environment and the behavioural environment	The first aim of this research was to establish that a model could be developed to represent the concept of office productivity, with the dimensions of physical environment and behavioural environment.

To answer hypothesis one a number of stages were undertaken. The main stages were as follows. Firstly, the creation of a theoretical framework that would include the concepts to be tested. Secondly, model development using statistical techniques, to establish the robustness of the model components. Thirdly, model validation, using a second data set. Finally, scale development for the concepts used in the model.

Whilst the theoretical framework was created by identifying gaps in the literature (Chapter 2), the concepts used in the framework were operationalised so that variables could be created and ultimately be included in a questionnaire (Chapter 3). At this stage, of the model development process, the concepts still remained theoretical.

To test the concepts, the multivariate statistical technique factor analysis was used to establish underlying meaning from the data from local authority dataset. To ensure that the analysis was robust, and appropriate, a seven-stage model-building process was adopted (Hair *et al*, 1995). The result of the first five stages of the model building process was the creation of seven components. The factor analysis had reduced the original 27 evaluative variables into seven underlying dimensions.

Table 6:1 Seven components of office productivity using the local authority dataset.

Factor	Name	Attributes
All		
1	Distraction	Interruptions, crowding, noise, privacy, overall atmosphere
2	Environmental services	Ventilation, heating, natural lighting, artificial lighting
3	Office layout	Personal storage, general storage, work area, desk, overall office layout, position of colleagues, circulation space
4	Interaction	Social interaction, work interaction, physical security, creative physical environment
5	Designated Areas	Informal meeting areas, formal meeting areas, quiet areas
6	Comfort	Décor, cleanliness, overall comfort
7	Informal interaction points	Position of equipment, refreshment areas

Using factor analysis, seven distinct components were created to represent office productivity. All the components created were reliable, using the Cronbach's alpha criterion, with the exception of the informal interaction points. However, the informal interaction points component was included, as the low Cronbach's alpha value could be caused by the fact that only two variables had loaded on to this component[35]. It was felt that at this stage of analysis the component revealed an insight into the dynamics of the office environment, and therefore it was deemed acceptable, although it is acknowledged that the factor was not as reliable as the other factors in the analysis.

[35] Generally the higher the number of variables loading on to a factor, the higher the Cronbach's alpha

It could be argued that the components environmental services, office layout, designated areas and comfort are representative of the physical environment (Whitley, 1996; Oseland, 1999 and 2004; Leaman and Bordass, 2000) whilst the components distraction, interaction and informal interaction points relate more to the behavioural environment. Whilst the physical components support the existing literature, the three behavioural components are new and therefore contribute to the body of knowledge.

The creation of the seven components appears to offer support for the hypothesis that a model can be developed to represent the concept of office productivity, with the dimensions of physical environment and behavioural environment.

Whilst the first five stages, of the seven-stage model, had created the seven components, stage six aimed to validate the components further. To establish the internal reliability of the seven components, factor analysis was conducted on a split sample of the original data set. To establish external reliability, and also the generalisability, of the components, factor analysis was conducted on a separate dataset, which was collected from the private sector.

The split sample factor analysis allowed the public sector data set to be split by work process, thereby aiming to demonstrate that the seven components were applicable to all the work patterns Table 6:2.

Table 6:2 Ways of working criteria adopted in this study

Way of Working	Flexibility (Autonomy)	Time with Colleagues (Interaction)	Sample Size
Individual Process	Very Low-Average	< 60 %	418
Group Process	Very Low-Average	> 60 %	302
Concentrated Study	High-Very High	< 60 %	184
Transactional Knowledge	High-Very High	> 60 %	93

Table 6:2 illustrates that generally the seven components were replicated in three of the four different work patterns tested. Only the transactional knowledge work type, i.e. high autonomy and high interaction, does not replicate all the seven components, the missing component being office layout. An explanation for this result could be that transactional knowledge workers have the autonomy to work outside the office, and therefore the office layout may not be as important a component to them when they are in the office.

Table 6:3 Component loading and reliability (Cronbach's Alpha scores) for staff reporting engagement in different modes of working

	Ways of Working			
Component	**Individual Process**	**Group Process**	**Concentrated Study**	**Transactional Knowledge**
Distraction	0.8115	0.888	0.759	0.8345
Comfort	0.7111	0.8927	0.8664	0.8721
Flexible Space	0.8073	0.8443	0.8579	0.8789
Interaction	0.8115	0.8442	0.8547	0.9071
Informal Interaction Points	0.4913	0.6703	0.7916	0.691
Environmental Services	0.7989	0.8552	0.7764	0.7784
Office Layout	0.8535	0.8534	0.8095	No Component

The three new dynamic components were generally replicated in all of the work patterns demonstrating internal reliability. The one notable exception being the informal interaction points for the work pattern individual process, which had a Cronbach's alpha of 0.4913. A possible explanation for this result could be the desk bound nature of individual process workers. Consequently having a chat at an informal interaction point, such as a coffee machine, may not be acceptable behaviour for office occupiers undertaking individual process work.

However, the split sample factor analysis strengthens the claim that a model can be developed to represent the concept of office productivity, with the dimensions of physical environment and behavioural environment. Collecting a second data set from a company in the private sector further strengthened the claim. This further analysis provided an opportunity to establish external reliability, and also the generalisability of the seven components obtained for the public sector data set.

The result of the private sector analysis demonstrated that the seven components found in the public sector data set were replicated in the private sector data set. The results demonstrate that both private and public sector office workers perceive the same underlying concepts with regards to office productivity. This supports the proposal that both public and private sector office workers have a common view of the underlying concepts of office productivity. Although it should be acknowledged that unique differences did appear, such as unique loadings of certain variables, the general seven components remained robust. The acknowledgement that the factors appeared in both the public sector and private sector dataset supported the proposal that both data sets could be combined to provide an overall factor analysis. The results for the combined dataset can be seen in Table 6:4.

Table 6:4 Seven components of office productivity created by combining both the local authority dataset with the private sector company data set.

Factor	Name	Attributes	Cronbach's alpha
All			0.95
1	Distraction	Interruptions, crowding, noise	0.80
2	Environmental services	Ventilation, heating, natural lighting, artificial lighting	0.82
3	Office layout	Personal storage, general storage, work area - desk, overall office layout	0.86
4	Interaction	Social interaction, work interaction, , creative physical environment, overall atmosphere, position relative to colleagues	0.86
5	Designated Areas	Informal meeting areas, formal meeting areas, quiet areas, privacy	0.85
6	Comfort	Décor, cleanliness, overall comfort, physical security, circulation space	0.88
7	Informal interaction points	Position of equipment, refreshment areas	0.60

It can be concluded that the same seven factors created in the both the private and public sector data sets appear in the combined data set. Therefore this is further supporting evidence for the first hypothesis that a model can be developed to represent the concept of office productivity, with the dimensions of physical environment and behavioural environment. The three new components, i.e. distraction, interaction and informal interaction points are further supported with Cronbach's alphas of 0.8, 0.86 and 0.6 respectively[36].

The final stage of the seven-stage model development was to develop a scale that could be used in subsequent statistical analysis. In an attempt to provide further evidence to support hypothesis one, and provide even more robust components, a factor analysis was undertaken with the combined data set exposed to stricter criterion, such as the Eigan value set at 1. This provided the results as shown in Table 6:5.

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[36] It is acknowledged that whilst the Cronbach's alpha for the component informal interaction points had increased, relative to the private and public data sets, it still remains relatively low. Future research could include additional informal interaction point questions, in an attempt to increase the Cronbach's alpha of this component.

Table 6:5 Four components of office productivity, and associated reliability, created from combined dataset and Eigan value set at 1.

Factor	Name	Attributes	Cronbach's alpha	Previous Factors
All			0.95	
1	Comfort	Ventilation, heating, natural lighting, artificial lighting, dĕcor, cleanliness, overall comfort, physical security,	0.89	Comfort Envrionmental Services
2	Office layout	Informal meeting areas, formal meeting areas, quiet areas, privacy, personal storage, general storage, work area - desk and circulation space	0.89	Office Layout Designated Areas
3	Interaction	Social interaction, work interaction, creative physical environment, overall atmosphere, position relative to colleagues, position relative to equipment, overall office layout and refreshments	0.88	Interaction Informal Interaction Points
4	Distraction	Interruptions, crowding, noise	0.8	Distraction

All of the four new components have Cronbach's alpha's greater than 0.8, thereby indicating a high internal reliability and ensuring that subsequent statistical analysis would be based on reliable foundations. It can be seen that the previous components of comfort and environmental services have merged to form a more generic representation of comfort. Likewise, the merging of the previous components office layout and designated areas creates a new office layout component. The previous informal interaction points and interaction components were absorbed into a new, more general, interaction component. The new distraction component appears as it did in the seven-component model.

It is proposed that the four new components add further support to hypothesis one. Since the components office layout and comfort appear to support the proposition that the office environment can be perceived as the physical environment, and distraction and interaction appear to support the proposition that the office environment can be perceived as a behavioural environment.

Previous research, which has provided evidence relating to the physical environment and occupier productivity, has tended to evaluate individual attributes and productivity (Whitley, 1996; Oseland, 1999 and 2004; Leaman and Bordass, 2000). This research differs, in that it incorporates a multi- item scale, thereby providing a greater understanding of the dimensions of comfort and office layout.

The creation of the behavioural environment dimension, with its components of interaction and distraction, also contributes to knowledge. This further contribution develops a greater understanding of the social dynamics, and the behavioural patterns, exerted in the office environment (Nathan and Doyle, 2002).

This study has provided evidence to support hypothesis one. A model can be developed to represent the concept of office productivity with the dimensions of physical environment and behavioural environment. It can therefore be concluded that a validated model has been developed, and in light of this study's research findings, the theoretical framework for office productivity can be redefined, as shown in Figure 6.3.

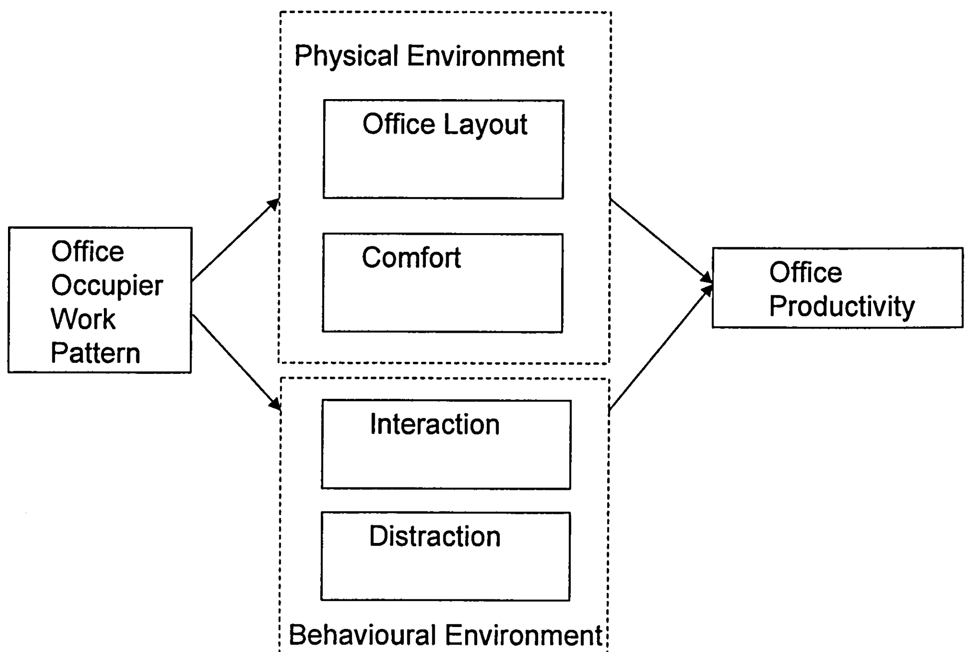

Figure 6.3 Validated theoretical framework of office productivity

Finally, in this section, the creation of the validated theoretical framework of office productivity contributes to knowledge, in that its measures are obtained from the office occupiers themselves. This addresses the criticism that traditional evaluations of property performance are obtained by observations of non-participants (Fleming, 2004). It could also be argued, and adds further support to the approach adopted in this study, that the occupier perspective is a necessary and integral part of understanding the behavioural dimension of the office environment (Fleming, 2004).

6.2.3 Comparison of office productivity components

Hypothesis Two: It is the behavioural components of office productivity that have a greater effect on productivity than the physical components.	The aim of this research was to establish that it is the different forms of communication, specifically conversation, that are the currency of a productive office[37]. Therefore it will be factors that enable interaction to occur, that will be seen as the factors that have the most positive impact of on office productivity.

To develop supporting evidence for the second hypothesis, two main stages of analysis were undertaken. Firstly, box plots were produced for the four concepts, layout, comfort, interaction and distraction, using the combined data set. Secondly, the four concepts were analysed for each of the four work processes, those being; individual process, group process, concentrated study and transactional knowledge work.

Initial analysis of the combined data set revealed that at best the office layout and comfort of the office environment were having a neutral effect on occupiers' productivity. It can be concluded, from this result, that whilst the literature has concentrated predominately on the office environment as a physical environment, there are still opportunities for improvement. It appears that the basic requirements of layout and comfort are not being addressed, which means that opportunities for

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[37] The notion that conversation is the currency of the modern organisation is accredited to Price and Shaw (1998)

productivity improvement exist by addressing the physical environment. These findings generally support the office productivity literature that has linked the physical environment to office occupiers' productivity (Whitley, 1996; Oseland, 1999 and 2004; Leaman and Bordass, 2000).

The behavioural components of interaction and distraction, appear to be having the most effect on perceived productivity. The results indicate that it is the interaction component that is perceived to be having the most positive effect on productivity, which supports the proposition that office environments are partly knowledge exchange centres (Becker & Steele, 1995). This result demonstrates that office occupiers value interaction at both a work level and a social level (Heerwagen *et al* (2004). The behavioural component distraction is the component that has the most negative effect on perceived productivity (Mawson, 2002; Olson, 2002). In contrast to Olson (2002) and Mawson (2002), this research measures distraction using a multi-item scale, thereby providing a richer understanding to the distraction concept.

Clearly the distraction component and the interaction components are related, as one person's interaction is another person's distraction. The interaction and distraction components contribute to knowledge because they establish an understanding of the behavioural environment within an office environment. The challenge for managers responsible for managing office environments is to maximise the interaction component, whilst at the same time attempting to minimise the distraction component. The solution to this paradox will be a combination of office work processes, office layouts, office protocols and organisational culture (Peterson & Beard, 2004).

The initial analysis provided supporting evidence for hypothesis two. It is the behavioural components of office productivity that have a greater effect on productivity than the physical components.

To develop further supporting evidence for hypothesis two, and also to add more contextual meaning to the results, the four concepts were analysed for each of the four work processes; individual process, group process, concentrated study and transactional knowledge work (Laing *et al,* 1998).

The findings of the four work process groups generally confirmed the findings of the total data set. The physical environment components of office layout and office comfort generally have a neutral effect on perceived productivity, and the behavioural components of interaction and distraction having the most effect, those being positive and negative respectively.

In the context of the individual process workers the positive result for interaction offers a further insight into this work pattern. Whilst, by definition, the individual process workers work largely on their own, the results indicate that they perceive the limited interaction they have with their colleagues as contributing to their productivity. To ensure that positive interactions are enabled, and not left to chance, consideration needs be given to the development of different kinds of space, such as break out areas and informal meeting points (Peterson & Beard, 2004). The benefits of creating such areas, is that interactions around peoples desks can be minimised, thereby the negative effects of distraction can be reduced (Olson, 2002).

The creation of such areas does not necessarily have to mean an increase in space requirement, as this new-shared space can be accommodated if some of the individual space is relinquished. Currently, the individual process workers perceive they are location required and have little autonomy with regards to where they work. Since the predominant style of work is individual work, the possibility exists for this kind of work to be undertaken away from the office environment, specifically the home environment (Lupton & Haynes, 2000). Clearly, the development of a solution to increase the productivity of individual process workers requires organisational culture and a management style that supports more flexible working (Becker & Steele, 1995)

The positive result for interaction, for the group process workers, supports the proposition that group process workers are dependent on their colleagues for their own productivity. This result indicates the benefits of collaborative work processes such as teamwork (Brenner & Cornell, 1994). Whilst interaction is perceived as positive, the distraction component is perceived as negative. It is proposed that the negative distraction component, for group process workers, can be reduced by greater consideration being placed on both the physical and social dynamics of the office environment.

The nature of group process work means that office occupiers that adopt this work process are predominately location required. This puts specific emphasis on providing the appropriate physical environment. Improvements in office layout for group process workers could be achieved by providing clearly defined group areas, (Peterson & Beard, 2004). The specific layout, and control of the comfort systems, could be achieved by localised agreements with the appropriate group of office occupiers. Extending this approach to office protocols could lead to localising agreements between groups of office occupiers. Adoption of office protocols acknowledges the behavioural environment, and therefore offers a possible solution to the interaction and distraction paradox (Sims, 2000; Brennan *et al*, 2002).

The results for the concentrated study work pattern offers opportunities to reconsider the most appropriate space requirement for this type of work pattern. The concentrated study worker spends a larger percentage of their time actually out of the office environment. Therefore providing this kind of worker with dedicated office space is an inefficient use of space. Although this work process is predominately individual knowledge work, the results indicate that office occupiers that adopt this work process value the interaction concept. The results also indicate distraction to be having the most negative impact on productivity.

A possible solution for concentrated study workers would be an environment designed on the principles of commons and caves (Hurst, 1995). The caves could be small cellular type offices allowing for private individual work. Alternately, since the results indicate that concentrated study workers spend time outside the office, the small cellular type offices could be provided on a shared basis. The commons area could be provided by informal meeting areas, thereby enabling the much-valued interaction to take place (Peterson & Beard, 2004). As a protocol for distraction free work, a cellular type office could be booked in advance. However working in the common areas signals your availability for interaction with other colleagues. The common space could be used on an ad hoc basis, thereby enabling random interactions and conversations.

The results for the transactional knowledge workers provide a profile of an office worker that values the office environment as a knowledge exchange centre (Becker & Steele, 1995). The transactional knowledge workers undertake the most variety of tasks when in the office environment, added to this the high level of interaction with colleagues, indicating a profile of a dynamic behavioural work pattern (Nathan & Doyle, 2002). As in previous work patterns, but to a greater extent, interaction is perceived as the component that has the most effect on office occupiers' productivity. This result is understandable, since the knowledge created and transferred by the transactional knowledge worker is very much dependent on the quality of interactions with other office occupants (Laing *et al,* 1998). To ensure optimum balance between interaction and distraction is achieved, then consideration needs to be given to both the behavioural environment and the physical environment. The behavioural environment could be addressed by the adoption of appropriate office protocols (Sims, 2000; Brennan *et al*, 2002). The physical environment could be addressed by consideration being given to "multi-activity" areas in the office layout, thereby providing an environment that is designed for a range of different uses.

This section has summarised the supporting evidence for the hypothesis that it is the behavioural components that have a greater impact on productivity than the physical components. The components interaction and distraction are constantly perceived as the components that have the most positive and most negative effect, respectively, on perceived productivity. The results are consistent in that they are repeated in all of the four work patterns analysed. The findings have implications for the office manager, as there is clearly a requirement to proactively manage the behavioural environment. The optimum balance between interaction and distraction has to be reached, and this will require the adoption of office protocols (Sims, 2000; Brennan *et al*, 2002). The physical environment can also play a role in achieving the optimum balance, by creating different kinds of work space, such as collaborative work space and space of private individual work (Peterson & Beard, 2004). The proportions of space allocation will be very much dependent on the adopted work pattern in the office environment. This study serves to broaden the debate, by identifying the need for a greater understanding of the behavioural (Nathan & Doyle, 2002), and cultural elements within an office environment (Turner & Myerson, 1998).

6.2.4 Work pattern analysis

Hypothesis Three: There is no significant difference between work patterns in terms of office productivity.	The final hypothesis aimed to establish if office occupiers, who adopt different work patterns, can be segmented based on differences of perceived productivity with regards to the physical environment and the behavioural environment.

To evaluate the evidence for the final hypothesis, two main stages of analysis were undertaken. Firstly, the categorical variables were evaluated, using Chi-squared analysis, to establish if statistical differences existed between the four work patterns. Secondly, the four concepts were analysed using ANOVA to establish if statistical differences existed between the four work patterns.

The results of the Chi-squared analysis revealed that no statistical differences existed between the public sector dataset and the private sector dataset for the four different work patterns. The indications of such a result being that both sectors have a similar range of work patterns.

Whilst no evidence was found to suggest that a relationship between age and work patterns existed, evidence that linked work pattern and gender was found. Statistical differences were found to indicate a gender bias, with more females undertaking group process work than males, and more males undertaking more concentrated study work than females.

Analysis of the results for time spent in the office and the allocation of dedicated desks revealed the most location required work pattern to be the group process workers. In contrast the work pattern that appears to have the most autonomy and flexibility in how they work is the concentrated study work pattern.

The categorical analysis provided evidence to support the proposition that the transactional knowledge workers undertake a variety of different tasks when in the office environment. This finding supports the proposal that transactional knowledge workers are both dynamic, and diverse, with regard to their work in the office environment (Laing *et al*, 1998), In contrast the individual process workers appear to undertake the least variety of tasks in the office environment. This finding supports the proposal that individual process workers undertake repetitive tasks with little scope for variation (Laing *et al*, 1998).

In summarising the categorical analysis, it can be concluded that statistical differences were found, however the differences established were generally supportive of, and in line with, the different work processes (Laing *et al*, 1998). One final finding of the categorical analysis was that 76% of respondents believed that when it comes to the effects on their productivity, the office environment has a high-very high level of importance. It can be concluded from this finding, that whilst there are a number of different elements that can affect an individual's productivity, the office environment is considered to be one of the major contributors.

The second stage of the evaluation of the final hypothesis was to establish if statistical differences existed, relative to the four concepts, between each of the four work patterns. The aim of such an analysis was to establish if office occupiers, that adopted different work patterns, could be segmented based on the differences of their perception of productivity with regards to the physical environment and the behavioural environment. The principal findings and conclusions of this second stage of analysis will now be summarised.

The results for the transactional knowledge worker and the concentrated study worker showed that no statistical difference existed between these two work patterns and how they evaluated the effects of comfort on their productivity. The common element between these two work patterns is the fact that they both involve knowledge work. The transactional knowledge worker undertakes collaborative knowledge work, whilst the concentrated study worker undertakes individual knowledge work (Laing *et al*, 1998). Also, both of these types of work pattern have the flexibility in where they work; if they feel uncomfortable in the office environment they can move to a more comfortable location. In contrast the process work patterns, both individual and group, are more location required thereby more dependent of the comfort systems provided in the office environment.

It can be concluded that with regards to the work patterns and the effects of comfort on perceived productivity two clear segments appear. One segment can be categorised as knowledge work, and the other can be categorised as process work. The process work segment perceives the comfort of the office environment to be having a more negative effect on their productivity than the knowledge workers, probably due to the lack of individual control over the office comfort systems. This finding is supportive of the notion that perceived productivity and perceived controls over office comfort systems are related (Whitley *et al*, 1995; Leaman & Bordass, 2000).

The findings for the office layout indicate that transactional knowledge workers perceive the effects of office layout differently from the other work patterns. There are no statistical differences between individual process workers, group process workers and concentrated study workers, and generally these work patterns perceive the layout of the office environment to be having a negative effect on their productivity. This finding demonstrates that a mismatch between the office layout and the office occupier work pattern has occurred (McGregor, 1994). In contrast the transactional knowledge workers are a statistically significant grouping, and perceive the office layout to be having a positive effect on their productivity. Clearly office layouts are not matching the requirements of three of the four work patterns analysed, and more importantly this mismatch of environment to work pattern is having a negative impact on their productivity (Mawson, 2002). The implication of this finding, for office designers, is that if improvements in office layout are to be achieved, then office occupiers need to be consulted at all stages of the layout design process (Laframboise *et al,* 2003). This approach would best ensure that a match between office layout and work process is achieved.

All of the four work patterns perceived interaction to be having a positive effect on their productivity. However, the transactional knowledge workers reported the highest positive results, which was significantly different from the other work patterns results. The findings indicate that two segments emerge, one containing the transactional knowledge workers, and the other containing the remaining three work patterns. The implication of this finding is that whilst the individual process workers and the concentrated study workers spend a large part of their time working alone, they value the behavioural element of interaction as much as the group process workers.

The findings of the concept distraction revealed that all the work patterns perceived distraction to be having a negative effect on their productivity (Olson, 2002). The findings could be segmented into two, one containing the transactional knowledge workers and the other containing the remaining three work patterns. The transactional knowledge workers segment result was not as negative as the other segment results. This finding indicates that this work pattern is a little more tolerant of distractions, probably due to the dynamic and interactive nature of transactional knowledge work.

In conclusion, significant differences did exist between work patterns and the concepts of office productivity. However, only two segments tended to emerge for each of the four concepts analysed. The work pattern transactional knowledge workers represented one separate segment, with the remaining three work patterns representing the other segment for the concepts of office layout, interaction and distraction. The two segments created for the comfort concept could be classified as a people that undertake process work, and people that undertake knowledge work.

6.3 Contribution to knowledge

It is proposed that the main contributions to knowledge of this study are as follows:

A major contribution of this study is the development of office productivity from a theoretical framework to a validated research method that allows reliable assessment of office productivity. The study's strength is that it is based on two sizable data sets, (996 respondents and 426 respondents) which when combined provide a data set of 1,422 responses. Whilst the data collected contains data about the physical characteristics of the office environment, it has in addition data pertaining to the behavioural environment. The categorical data collected provides a unique opportunity to undertake an analysis by work process type.

This study adds directly to the workplace literature by broadening the debate. The debate around office environments has tended to revolve around open-plan offices and cellular offices. The main line of argument developed tends to be one of cost reduction, i.e. open-plan office are more cost effective than cellular offices. The logical conclusion of this line of argument is that as many people as possible should be put into open-plan offices. Unfortunately, this one-size fits all approach does not accommodate different work patterns. Whilst some work patterns require the occupant to work privately, others require more group type working. This study allows office occupants to be categorised by their work pattern, thereby allowing a more detailed analysis of office occupants to be undertaken. Also the analysis by work pattern gives an indication as to the office culture. The degree of autonomy an office worker has will be very much determined by the type of prevailing culture.

A further contribution of this study is a broadening of the understanding of the office environment. Traditionally, the office environment has largely been considered to be the physical environment. The main physical components are office layout and office comfort. This approach tends to assume that the office occupant is a passive element of the office environment. This study has established that the behavioural environment is an integral component of office productivity and demonstrated that it is the dynamic elements of the office environment that enable knowledge creation and knowledge transfer, and ultimately productivity, through various forms of communication.

Managers responsible for office environments can use the techniques, and the analysis procedures, developed to evaluate the productivity of office environments[38]. This would assist managers to identify office environments that were having a negative effect on its occupants, and the model developed would assist in establishing the major cause of the those negative impacts. The positive results can be just as important to the manager as the negative, as this is an indication as to areas in the office environment that are working correctly. A comparative approach between offices can allow best practice solutions to be transferred from one office to another. Models developed in this study can be used over time, thereby providing a monitoring system that continually evaluates the match between the occupants and their office environment. Such information can be used to adapt the office environment to meet changing office occupant demands.

6.4 Limitations

The growth of facilities management has led to the creation of a new professional body, with the accompanying development of a new academic discipline. However, the academic developments have tended to lag the professional developments,

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[38] A number of projects have been undertaken which have applied the techniques developed in this study.

with many in the academic community calling for more research based upon firm philosophical stances. There is a requirement for the facilities management research community to develop theoretical frameworks that are supported by research evidence. Whilst this study has attempted to address these issues, it is acknowledged that limitations in this study exist.

This research has adopted a philosophical stance that has led to a positivist epistemology. Whilst the majority of office evaluation research adopts a similar stance, it could also be identified as a possible limitation. It could be argued that the office occupier's view of their productivity is less tangible, and is more of a socially constructed nature. This stance would suggest that there are a number of different views with regards to office productivity, and not one unifying truth as in the positivist stance. It is acknowledged that this stance would lead to a different perspective on office productivity, however since research into office productivity is in the relatively early stages, it is suggested that this area would benefit from both types of research. It is only when both research stances are published, and placed into the research community, that workplace research knowledge can be developed.

The development of the theoretical framework was mainly achieved as a result of the literature review. The concepts of office productivity were established by identifying both what was already included in the literature, the physical environment, and just as importantly what had not been addressed in the literature, the behavioural environment. However, the operationalization of the concepts to indicators was in part based on existing literature, and in part based on the researcher's own expertise. It is acknowledged that an alternative stance would have been to use focus groups to assist in operationalization of the concepts and the identification of the appropriate variables or indicators[39]. It could also be argued that the number of indicators used restricts the concepts developed. This study contained 27 evaluative variables, which can be perceived as a limitation. Therefore, whilst this study claims to evaluate new concepts of office productivity, it cannot be claimed that his study evaluates all the concepts of office productivity.

[39] This approach was attempted at the early stages of the research and subsequently discarded as the focus group had difficulty developing the concept of office productivity beyond that of the physical environment.

Limitations existed with regards the sampling strategies adopted. The local government data set was obtained for a research club, and although the participating authorities were geographically disperse, it could not be considered to be a representative sample of local authority offices. Therefore, claims of generalisability would need to be confined to the population from which the sample data were collected. The data for the private sector company were collected from a single organisation, therefore, claims of generalisability have to be contained to that organisation. It is acknowledged that to obtain a representative sample of private sector offices, a cross sectional survey would have to undertaken across a number of different firms. It should be also acknowledged that both sampling strategies were restricted by both time and cost constraints. Whilst limitations of sampling strategies have been identified, it should also be reiterated that the development of the office productivity evaluation model was based on two sizable data sets. Therefore, the ability to make statistical inferences is considered to be less of an issue.

The chosen method for model development was factor analysis, which has its own set of limitations. Factor analysis was used as a data reduction method to establish underlying concepts. However, whilst data reduction techniques assist in understanding, it could also be argued that the uniqueness, and richness, of the original data is lost. However this study attempted to capture the richness of the original data by including it in the creation of summated scales. A general criticism levelled at factor analysis is that it will always create factors, whether or not what is revealed has any real meaning. Also the naming of the factors created is a subjective process, and dependent on the researcher's research agenda. This research has attempted to address these issues, however it is acknowledged that the component informal interaction points was named based on only two variables, and a Cronbach's alpha of less than 0.6. It was included in the initial findings, as it was believed to add an additional context to the understanding of the behavioural environment. However, in the development of more robust components for subsequent statistical analysis, the informal interaction points component was absorbed as part of the more generic interaction component.

6.5 Further research

The actual measurement of productivity used in this study is self assessed productivity; the development of other more tangible metrics of measurement for productivity would allow for the possibility to triangulate findings. Also, the inclusion of additional evaluative variables would assist in establishing the richness and understanding of the concepts developed, specifically the component distraction, which has generally the most negative impact on productivity but still requires further development. Additionally, the inclusion in the questionnaire of open-ended questions would provide the respondent the opportunity to comment on office productivity in their own voice. The inclusion of such qualitative data would provide an opportunity to contextualise the quantitative data collected in the questionnaire[40].

How organisational culture, more specifically office culture, and management style link to office productivity is a further area for development. This research used four different work patterns as an indication of different management styles. The concentrated study workers and transactional knowledge workers perceived that they had freedom to work flexibly, whilst the individual process workers and the group process workers perceived themselves to be largely location required. The development of management style and cultural metrics would greatly assist in understanding the behavioural environment. Aligned to this kind of research, and a possible linkage between the physical environment and the behavioural environment, would be an evaluation of how cultural cues are sent through the use of the physical environment.

This area of research would benefit from further classification of the office occupiers. A greater understanding of the individual could be obtained if personality type questions were included at the questionnaire stage. A standard personality test, such as the Myers Briggs, could be adopted thereby allowing classification of respondents by personality type. Similarly, questions that relate to how the

[40] This approach has subsequently been adopted in a number of research projects. A report of one of the research projects is presented in Appendix K.

individual works in groups could be included, therefore establishing a better understanding of group dynamics and group behaviour[41].

Whilst this research was based on two cross sectional surveys, this study could be developed further by the adoption of a longitudal approach. A longitudal study would provide an opportunity to establish, in the first instance, a base line data set, so that subsequent evaluations would have terms of reference. This constant review of the office productivity would enable deviations to be established. As part of the longitude design it is suggested that both quantitative data and qualitative data should be collected. The quantitative data could be gathered using the survey method, and the qualitative data could be collected using focus groups and interviews. It is proposed that both forms of data would be useful, but for different purposes, during the period of study. The quantitative data could establish what the issues were with regards to office productivity, and the qualitative data could be used to establish the context, or the meaning, of the quantitative data. It is proposed that this iterative process that includes both quantitative data collection and qualitative data collection would provide insight into the changing, and dynamic, nature of the office environment.[42]

Finally, a possibility exists for observational and ethnographic type of research to be undertaken to further develop the understanding of the relationship between the behavioural environment and the physical environment. This kind of study could establish the movements of people within the office, with special emphasis being placed on the parts of the office that facilitate and enable interaction and the parts of the office that represent blockages and distractions to the office occupiers. Integrated into this study would be an assessment of the quantity, and quality, of the conversations undertaken in the office environment. If modern office environments are becoming more like knowledge exchange centres, then it seems appropriate to establish the optimum balance between collaborative interactive space and distraction free private individual space.

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[41] A possible technique would be one based on the Belbin Team Roles.

[42] The author has already undertaken a longitudal study based on this proposal, but due to confidentiality reasons the results cannot be included in this thesis.

6.6 Reflections

This study has identified the difficulty that previous researchers have had in identifying metrics, and appropriate data collection techniques, for office productivity. Evidenced by the lack of detailed research findings, it is clearly a research area that is in the early stages of its development. The literature, that has research credibility, has tended to adopt traditional scientific methods. This could be because the dominant research paradigm, for the related professional disciplines associated with workplace evaluation, has tended to be that of positivism. In fact this study adopts similar scientific techniques, although it differs significantly from previous studies in that it opens up the debate on office productivity from that of one revolving purely around the physical environment, to include the behavioural components of office productivity.

These findings also indicate that this area of research is interdisciplinary, with specific developments required between the areas of facilities management and environmental psychology. The implications for the facilities manager, responsible for office provision, are that greater consideration needs to be given to the behavioural elements of interaction and distraction. The ultimate aim would be to establish the right balance between collaborative interactive workspace and private distraction free workspace.

Finally, reflecting on my own journey during this research process, it is clear that the whole process has been far more complex than originally envisaged. This study has required both persistence and good time management skills. Whilst this research has allowed a further development of my statistical abilities, it has also broadened my appreciation of the behavioural elements within the office environment. This new dimension to office environments is an area I personally would like to develop. It is hoped that this research will stimulate discussion and provide the basis for further research.

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Does property benefit occupiers? An evaluation of the literature

Occupier.org Report Number 1, October 2000

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Executive overview

If occupiers are to be able to make correct decisions on property they, or their advisors, need to understand how it contributes, not only to costs but more importantly to the business delivery of the organisation. The publicly available literature, despite some claims and examples, does not yet provide this knowledge.

Introduction

The results of this first Occupier.org study are presented on this site in three levels. The raw data is evaluated in the **database .** The **full report** that follows draws those contributions into a cohesive thread acknowledging relevant source material. This overview, without attributions, summarises the main messages.

Interest in 'new workplaces' is reaching fad status with publications rising exponentially. With a few notable exceptions most of this interest is pushed by practitioners, advisers or professionals rather than pulled by line managers or even business and organisational theorists. One sign of the explosion is the plethora of new terminology as property or real-estate specialists, facilities managers and workplace designers all lay claims to a, or often the, strategic role; claims whose evidence is frequently lacking.

Property supply

In the UK in particular, despite new forms of service offering being advertised to the market, and despite shortening lease terms (whether for reasons of supply and demand or as a true sign of a shift in the marketplace is unclear) traditional approaches to property procurement still dominate. It is at least arguable that they are more deeply embedded and discouraging of innovation than in the USA or Scandinavia, though comparative research is hard to find.

A theoretical underpinning for occupation decisions does not exist. The new market emphasis on intellectual capital and the growing gap between market values and asset values is leading to questions of whether, on the one hand the markets properly value property assets held by non-property companies, and on the other whether such companies need to hold property. Some research suggests that, in higher technology industries, firms with lower property holdings derived superior stock-market value over the period 1983-1994.

Costs

Information on true occupancy costs, and especially whole life costs, is frequently not available. Life cycle costs cannot be considered without knowing the impact of the workplace on operational factors (e.g. staff turnover) and the data do not exist. More disconcertingly, the influence of property on the feedback from customer perceptions to business income is poorly understood, outside sectors such as retail where it has always been more immediately obvious.

Property acquisition and operational costs are the second largest expense, after salaries, for most office-based organisations, yet they are not necessarily gathered to any standard. Moreover IT costs are frequently considered, and managed, separately, a factor that is bound to impede decisions, such as workplace investments, that may involve a trade-off between physical and virtual space.

Operations

Space charging is the most usually recommended method of allocating costs to individual business units or product lines. Whether it is effective in persuading departments to make more efficient or effective use of their space is unclear. The topic has received little attention.

Service level agreements and output specifications for hard and soft FM services are another operational practice much recommended in theory (again with a bias towards advisers or service providers in the recommending group) but their effectiveness in practice has again received little attention. Many organisations, whether or not they contract in or manage FM in-house, have a tendency to prefer a significant measure of control on inputs, staff numbers and budgets. Some have found that in practice the effort devoted to the construction of service levels fails to justify the return and have abandoned them in favour of benchmarking (properly applied) and demonstrations of year on year improvement. Others have found that service levels expressed in terms of failure to comply with minimum standards fail to encourage a customer focus.

The focus of much operational FM on costs and technical measures is in any case misplaced. A variety of schemes for assessing staff perceptions of workplace exist but often have only indirect links to measures of productivity. Again there is a knowledge gap. The functional (as opposed to the physical or financial) obsolescence of buildings has been little studied and even less attention has been paid to the impact of workplaces on the changing nature of work in the knowledge economy.

Better FM measurement practice would seem to lie in the development of more holistic, balanced scorecard style, measurement systems where business relevant measures of customer impact are included. In some cases, say retail sites or hotels, customer footfall provides an obvious indication of business impact. In others, say higher education, hospitals (in the UK) and perhaps call / service centres, the feedback is beginning to be appreciated. For mainstream offices it tends to remain invisible despite some evidence in practice of well-designed workplaces facilitating faster knowledge creation and dissemination.

Workplace design

The theoretical basis of new workplace design, matching working environment to different work demands, is well established. Recent examples in the creation of branded networks of telecentres to support completely mobile workers suggest that the cafe style drop in office will become increasingly important.

The evaluation of new workplace environments - especially the claims for the benefits of what still tend to be termed open-plan, non-hierarchical environments - is split. Some high profile attempts have failed with occupiers reverting to traditional executive offices. Other examples are claimed as critical to new cultures and business success.

Among reported benefits are

1. reduced absenteeism
2. easier recruitment
3. reduced turnover
4. improved morale and customer service
5. faster development of new products and ideas
6. higher knowledge worker productivity
7. reduced environmental and travel costs, for staff and businesses

The promotion of new ways of working and new workplace styles may have ignored differences of individual psyche. Two people doing essentially similar jobs may have genuinely different needs from their working space. The argument is however obscured by questions of status and organisational culture. Management attitudes appear to have a large part to play in the success or failure of new forms of working. A common claim in the successful cases is that the objective, from day 1, was increased output rather than simply reduced cost. The point is made that the rhetoric of the former frequently obscures an intention that is much more focussed on cost.

Productivity

The business value of workplace initiatives is apparently best considered as part of the wider question of managing and measuring knowledge work. The link to organisational culture, widely made in the knowledge management arena, is beginning to be appreciated in the workplace design arena. The term 'process architecture' has recently been suggested to indicate the interaction of the designer with the culture and unwritten design rules of the organisation. Changes in workplace may enable changes of culture but only, perhaps, if they are accompanied by changes in managerial thinking and belief systems. If the modern school of management thinking is correct in the assertion that new managerial paradigms are needed in the new economy, or to the extent that it is true, then they may also be a needed to make a success of new workplaces. Conversely, the creation of physical (and perhaps virtual) space may be the most under-utilised managerial tool of the knowledge era; a claim that is only beginning to be investigated.

National differences

The cultural reactions to space, while undoubtedly being influenced by national cultures, also have a significant generic element. However, there are particular factors of the operation of the property market in the UK that may make the lack of understanding more of a problem. We have not found specific research but experience of the Scandinavian market, where owner occupation is more common, suggests a more direct involvement of the occupying organisation in how their premises are designed and built. In the USA shorter lease terms and greater movement of businesses may make experimenting with new forms of both financing and design easier. Conversely, the argument that key staff will leave if they are not given private offices is made more strongly in American literature.

Future priorities

We have summarised what is and is not known about the impact of property and workplace on occupiers' businesses. It is clear that there are significant gaps in both the professional and business literature. It is also clear that the issue, if it is to be understood, needs to be considered from a business perspective. The question is less how does property benefit occupiers and more how do occupiers secure maximum benefits from property. It is a management issue rather than a design issue.

Research needs to provide

1. Standard codes for treating full occupancy costs
2. Guidelines for the trade-off between life cycle costs and benefits (individual, organisational and environmental)
3. Validated studies of the impact of workplaces on business productivity and market value
4. Further validated studies of the links between market value and property ownership
5. Predictive models of functional obsolescence
6. An understanding of the links between workplaces, organisational culture, and knowledge creation

WORKPLACE PERFORMANCE QUESTIONNAIRE

Your authority is working with Sheffield Hallam University to Benchmark the workplace provided.

Please take a few minutes to fill in this questionnaire about you and your working environment

This questionnaire aims to investigate whether your office environment is having either a positive or negative effect on your work performance.

The information gathered will be **CONFIDENTIAL**

Please answer the questions by putting a cross in the most appropriate box ☒

We would like to take this opportunity to thank you for spending a few moments completing this questionnaire and request that it is returned to the person named at the end of the questionnaire by **15 August 2000**

GENERAL

Name of Authority

....

Name of your Department

....

Do you work in a open-plan or cellular office?	Open Plan	☐	Cellular	☐
Do you have a dedicated desk?	Yes	☐	No	☐

ABOUT YOU

Gender Male ☐ Female ☐

How old are you?

☐	☐	☐	☐	☐
<25	25-35	36-45	46-55	>55

Which of the following best describes your work?

☐	☐	☐	☐	☐
Administration	Professional	Senior Professional	Manager	Other

WAYS OF WORKING

What percentage of time do you spend directly working with colleagues?

☐	☐	☐	☐	☐
0-20%	21-40%	41-60%	61-80%	81-100%

What percentage of time, in your working week, do you spend in the office?

☐	☐	☐	☐	☐
0-20%	21-40%	41-60%	61-80%	81-100%

How much flexibility do you have to work where, when and how you wish?

☐	☐	☐	☐	☐
Very Low	Low	Average	High	Very High

What variety of tasks do you undertake when in the office?

☐	☐	☐	☐	☐
Very Low	Low	Average	High	Very High

OFFICE FACILITIES (Functional space)

In your opinion, in your current office, what effect do the following office facilities have on your personal productivity? (Mark only one box per item)

	Very Negative	*Negative*	*Neutral*	*Positive*	*Very Positive*
Work area i.e. Desk	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
Personal Storage	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
General Storage	☐	☐	☐	☐	☐
Formal Meeting Areas	☐	☐	☐	☐	☐
Informal Meeting Areas	☐	☐	☐	☐	☐
Quiet Areas	☐	☐	☐	☐	☐
Circulation Space i.e. walkways	☐	☐	☐	☐	☐
Position relative to colleagues	☐	☐	☐	☐	☐
Position relative to photocopier, fax etc	☐	☐	☐	☐	☐
Refreshment, Tea point etc	☐	☐	☐	☐	☐
Overall office layout	☐	☐	☐	☐	☐

ENVIRONMENTAL CONDITIONS

In your opinion, in your current office, what effect do the following environmental conditions have on your personal productivity? (Mark only one box per item)

	Very Negative	*Negative*	*Neutral*	*Positive*	*Very Positive*
Heating	☐	☐	☐	☐	☐
Natural Lighting	☐	☐	☐	☐	☐
Artificial Lighting	☐	☐	☐	☐	☐
Ventilation	☐	☐	☐	☐	☐
Noise	☐	☐	☐	☐	☐
Cleanliness	☐	☐	☐	☐	☐
Décor	☐	☐	☐	☐	☐
Overall physical comfort	☐	☐	☐	☐	☐

SPACE AND YOU

In your opinion, in your current office, what effect do the following elements have on your personal productivity?
(Mark only one box per item)

	Very Negative	*Negative*	*Neutral*	*Positive*	*Very Positive*
Physical Security	☐	☐	☐	☐	☐
Social Interaction	☐	☐	☐	☐	☐
Work Interaction	☐	☐	☐	☐	☐
Creative Physical Environment	☐	☐	☐	☐	☐
Privacy	☐	☐	☐	☐	☐
Interruptions	☐	☐	☐	☐	☐
Crowding	☐	☐	☐	☐	☐
Overall Atmosphere	☐	☐	☐	☐	☐

FINAL COMMENTS

Relative to other factors that can effect your work performance, how important to you is your physical working environment?

☐	☐	☐	☐	☐
Very Low	Low	Average	High	Very High

ANY OTHER COMMENTS

Please make any comments about how you feel your work performance is affected by your office environment.

Please return to:

Authority Contact:

Appendix C: Local authority covering letter

27 July 2000

Direct line: 0114 225 4006

Direct fax: 0114 225 4038

Email: b.p.haynes@shu.ac.uk

«Title» «FirstName» «LastName»

«JobTitle»

«Company»

«Address1»

«Address2»

«City»

«PostalCode»

Dear «FirstName»

Local Government Facilities Management Research and Application Forum

Research Project C: Creating Flexible Space

Please find enclosed copies of this year's questionnaires for the above project.

These questionnaires aim to establish a relationship between the working environment and the performance of the occupiers.

We hope to establish a statistically valid norm against which new office initiatives can be assessed.

I would be grateful for your assistance with this project as we intend to gather a large amount of data from the various authorities.

Could you:

1) Copy and distribute the "Workplace Performance Questionnaire" to all staff in an office in your authority that in your opinion represents the "average" office environment for your authority. You may, if you wish, submit two further evaluations. These may be "above average" and "below average".

2) Act as a collection point in your authority for the "Workplace Performance Questionnaire". The more questionnaires gathered, the greater the statistical validity.

3) Fill in a "Workplace Questionnaire" for each office evaluated. And attach to the completed Workplace Performance Questionnaires.

4) Return questionnaires by 18 August or earlier if possible. We aim to undertake case study visits in September and October so the data needs to be returned and analysed before then.

I will on annual leave during the data gathering process, so if you have any queries regarding any of the questions or definitions please contact either; Prof. If Price (Ext. 4032) or Helen Agahi (Ext. 4029).

I will be most grateful if you would please answer all the questions as fully and accurately as possible, the analysis will only be as meaningful and accurate as the data you provide.

I look forward to receiving your questionnaires.

With best wishes

Yours sincerely

Barry Haynes

Appendix D: Correlation matrix for local authority data set

	Workarea, Desk	Personal storage	General storage	Formal meeting areas	Informal meeting areas	Quiet areas	Circulation space	Position colleagues	Position equipment	Refreshment	Overall office layout	Heating	Natural lighting	Artificial lighting	Ventilation	Noise	Cleanliness	Decor	Overall comfort	Physical Security	Social Interaction	Work Interaction	Creative physical environment	Privacy	Interruptions	Crowding	Overall atmosphere
Workarea, Desk	1.00	0.62	0.49	0.36	0.32	0.36	0.45	0.52	0.30	0.29	0.63	0.34	0.37	0.37	0.36	0.40	0.40	0.42	0.58	0.36	0.34	0.42	0.46	0.42	0.38	0.41	0.53
Personal storage	0.62	1.00	0.68	0.41	0.38	0.42	0.43	0.41	0.27	0.32	0.56	0.36	0.29	0.33	0.37	0.36	0.38	0.40	0.50	0.33	0.29	0.36	0.45	0.41	0.39	0.41	0.47
General storage	0.49	0.68	1.00	0.43	0.43	0.42	0.51	0.41	0.29	0.29	0.59	0.39	0.35	0.37	0.43	0.34	0.43	0.39	0.53	0.33	0.30	0.38	0.46	0.42	0.39	0.42	0.47
Formal meeting areas	0.36	0.41	0.43	1.00	0.70	0.58	0.42	0.32	0.24	0.29	0.44	0.31	0.29	0.31	0.32	0.33	0.39	0.41	0.44	0.30	0.26	0.31	0.44	0.39	0.33	0.32	0.41
Informal meeting areas	0.32	0.38	0.43	0.70	1.00	0.66	0.42	0.30	0.25	0.33	0.43	0.28	0.29	0.30	0.32	0.37	0.36	0.40	0.44	0.29	0.26	0.32	0.45	0.43	0.33	0.33	0.40
Quiet areas	0.36	0.42	0.42	0.58	0.66	1.00	0.49	0.33	0.28	0.33	0.49	0.32	0.35	0.30	0.38	0.41	0.41	0.47	0.49	0.26	0.24	0.34	0.48	0.55	0.41	0.34	0.43
Circulation space	0.45	0.43	0.51	0.42	0.42	0.49	1.00	0.46	0.38	0.34	0.61	0.43	0.38	0.41	0.39	0.41	0.51	0.50	0.55	0.38	0.32	0.37	0.47	0.43	0.40	0.46	0.52
Position colleagues	0.52	0.41	0.41	0.32	0.30	0.33	0.46	1.00	0.35	0.34	0.56	0.30	0.32	0.32	0.32	0.39	0.33	0.32	0.47	0.30	0.44	0.48	0.42	0.37	0.33	0.39	0.50
Position equipment	0.30	0.27	0.29	0.24	0.25	0.28	0.38	0.35	1.00	0.41	0.43	0.28	0.24	0.25	0.21	0.30	0.33	0.28	0.35	0.26	0.31	0.33	0.33	0.28	0.28	0.27	0.34
Refreshment	0.29	0.32	0.29	0.29	0.33	0.33	0.34	0.34	0.41	1.00	0.44	0.26	0.29	0.26	0.26	0.24	0.34	0.34	0.35	0.27	0.30	0.28	0.34	0.32	0.20	0.23	0.34
Overall office layout	0.63	0.56	0.59	0.44	0.43	0.49	0.61	0.56	0.43	0.44	1.00	0.41	0.47	0.47	0.49	0.49	0.55	0.59	0.70	0.39	0.38	0.46	0.57	0.54	0.48	0.55	0.67
Heating	0.34	0.36	0.39	0.31	0.28	0.32	0.43	0.30	0.28	0.26	0.41	1.00	0.47	0.43	0.60	0.35	0.45	0.40	0.53	0.36	0.22	0.28	0.38	0.33	0.30	0.31	0.42
Natural lighting	0.37	0.29	0.35	0.29	0.29	0.35	0.38	0.32	0.24	0.29	0.47	0.47	1.00	0.54	0.56	0.30	0.47	0.45	0.54	0.33	0.22	0.27	0.38	0.46	0.30	0.31	0.47
Artificial lighting	0.37	0.33	0.37	0.31	0.30	0.30	0.41	0.32	0.25	0.26	0.47	0.43	0.54	1.00	0.55	0.39	0.48	0.45	0.51	0.36	0.24	0.29	0.38	0.37	0.38	0.39	0.48
Ventilation	0.36	0.37	0.43	0.32	0.32	0.38	0.39	0.32	0.21	0.26	0.49	0.60	0.56	0.55	1.00	0.46	0.48	0.45	0.61	0.34	0.28	0.33	0.46	0.48	0.38	0.41	0.53
Noise	0.40	0.36	0.34	0.33	0.37	0.41	0.41	0.39	0.30	0.24	0.49	0.35	0.30	0.39	0.46	1.00	0.42	0.41	0.50	0.28	0.27	0.31	0.44	0.48	0.54	0.52	0.51
Cleanliness	0.40	0.38	0.43	0.39	0.36	0.41	0.51	0.33	0.33	0.34	0.55	0.45	0.47	0.48	0.48	0.42	1.00	0.75	0.67	0.43	0.33	0.36	0.53	0.46	0.37	0.40	0.53
Decor	0.42	0.40	0.39	0.41	0.40	0.47	0.50	0.32	0.28	0.34	0.59	0.40	0.45	0.45	0.45	0.41	0.75	1.00	0.70	0.36	0.30	0.33	0.53	0.47	0.35	0.40	0.53
Overall comfort	0.58	0.50	0.53	0.44	0.44	0.49	0.55	0.47	0.35	0.35	0.70	0.53	0.54	0.51	0.61	0.50	0.67	0.70	1.00	0.44	0.39	0.46	0.60	0.56	0.43	0.49	0.67
Physical Security	0.36	0.33	0.33	0.30	0.29	0.26	0.38	0.30	0.26	0.27	0.39	0.36	0.33	0.36	0.34	0.28	0.43	0.36	0.44	1.00	0.45	0.43	0.40	0.34	0.29	0.29	0.44
Social Interaction	0.34	0.29	0.30	0.26	0.26	0.24	0.32	0.44	0.31	0.30	0.38	0.22	0.22	0.24	0.28	0.27	0.33	0.30	0.39	0.45	1.00	0.74	0.48	0.29	0.21	0.24	0.51
Work Interaction	0.42	0.36	0.38	0.31	0.32	0.34	0.37	0.48	0.33	0.28	0.46	0.28	0.27	0.29	0.33	0.31	0.36	0.33	0.46	0.43	0.74	1.00	0.52	0.38	0.29	0.31	0.56
Creative physical environment	0.46	0.45	0.46	0.44	0.45	0.48	0.47	0.42	0.33	0.34	0.57	0.38	0.38	0.38	0.46	0.44	0.53	0.53	0.60	0.40	0.48	0.52	1.00	0.58	0.44	0.42	0.62
Privacy	0.42	0.41	0.42	0.39	0.43	0.55	0.43	0.37	0.28	0.32	0.54	0.33	0.46	0.37	0.48	0.48	0.46	0.47	0.56	0.34	0.29	0.38	0.58	1.00	0.60	0.49	0.56
Interruptions	0.38	0.39	0.39	0.33	0.33	0.41	0.40	0.33	0.28	0.20	0.48	0.30	0.30	0.38	0.38	0.54	0.37	0.35	0.43	0.29	0.21	0.29	0.44	0.60	1.00	0.62	0.53
Crowding	0.41	0.41	0.42	0.32	0.33	0.34	0.46	0.39	0.27	0.23	0.55	0.31	0.31	0.39	0.41	0.52	0.40	0.40	0.49	0.29	0.24	0.31	0.42	0.49	0.62	1.00	0.56
Overall atmosphere	0.53	0.47	0.47	0.41	0.40	0.43	0.52	0.50	0.34	0.34	0.67	0.42	0.47	0.48	0.53	0.51	0.53	0.53	0.67	0.44	0.51	0.56	0.62	0.56	0.53	0.56	1.00

Appendix E: Anti-image correlation matrix for local authority data set

	Workarea, Desk	Personal storage	General storage	Formal meeting areas	Informal meeting areas	Quiet areas	Circulation space	Position colleagues	Position equipment	Refreshment	Overall office layout	Heating	Natural lighting	Artificial lighting	Ventilation	Noise	Cleanliness	Decor	Overall comfort	Physical Security	Social Interaction	Work Interaction	Creative physical environment	Privacy	Interruptions	Crowding	Overall atmosphere
Workarea, Desk	0.95	-0.35	0.06	-0.03	0.04	0.04	-0.01	-0.17	0.00	0.05	-0.19	0.01	-0.07	-0.03	0.08	-0.04	0.04	0.03	-0.17	-0.06	0.03	-0.06	-0.02	-0.01	-0.01	0.01	-0.01
Personal storage	-0.35	0.92	-0.45	-0.06	0.04	-0.07	0.05	0.00	0.03	-0.09	-0.02	-0.06	0.08	0.02	0.00	-0.01	0.04	-0.06	0.03	-0.04	0.01	0.01	-0.03	0.00	-0.02	-0.03	-0.02
General storage	0.06	-0.45	0.94	-0.04	-0.09	0.03	-0.14	-0.01	0.00	0.05	-0.16	-0.03	-0.01	-0.02	-0.07	0.09	-0.06	0.11	-0.06	0.02	0.00	-0.05	-0.03	0.01	-0.04	-0.04	0.06
Formal meeting areas	-0.03	-0.06	-0.04	0.94	-0.47	-0.14	-0.02	-0.02	0.01	0.01	0.01	-0.03	0.01	-0.01	0.01	0.04	-0.04	-0.03	0.00	-0.02	0.00	0.01	-0.04	0.04	-0.03	0.00	-0.01
Informal meeting areas	0.04	0.04	-0.09	-0.47	0.91	-0.35	0.00	0.02	0.01	-0.10	0.02	0.03	0.02	-0.04	0.04	-0.07	0.05	0.00	-0.04	-0.05	-0.01	0.01	-0.04	-0.02	0.04	-0.03	-0.01
Quiet areas	0.04	-0.07	0.03	-0.14	-0.35	0.94	-0.15	0.00	-0.01	-0.02	-0.04	-0.01	-0.04	0.08	-0.04	-0.07	0.03	-0.10	0.01	0.07	0.07	-0.09	-0.03	-0.20	-0.06	0.09	0.05
Circulation space	-0.01	0.05	-0.14	-0.02	0.00	-0.15	0.97	-0.11	-0.09	0.00	-0.15	-0.12	0.01	-0.05	0.07	-0.01	-0.08	-0.05	0.01	-0.07	0.00	0.03	-0.01	0.03	0.00	-0.10	-0.02
Position colleagues	-0.17	0.00	-0.01	-0.02	0.02	0.00	-0.11	0.97	-0.06	-0.07	-0.14	-0.01	-0.04	-0.01	0.04	-0.08	0.03	0.08	-0.03	0.06	-0.11	-0.11	0.01	0.00	0.03	-0.06	-0.03
Position equipment	0.00	0.03	0.00	0.01	0.01	-0.01	-0.09	-0.06	0.95	-0.24	-0.11	-0.08	0.00	-0.02	0.10	-0.05	-0.07	0.06	-0.02	0.00	-0.06	-0.05	-0.02	0.02	-0.07	0.01	0.04
Refreshment	0.05	-0.09	0.05	0.01	-0.10	-0.02	0.00	-0.07	-0.24	0.95	-0.14	-0.03	-0.05	0.00	0.01	0.02	-0.04	-0.03	0.05	-0.04	-0.09	0.06	-0.01	-0.06	0.08	0.02	0.00
Overall office layout	-0.19	-0.02	-0.16	0.01	0.02	-0.04	-0.15	-0.14	-0.11	-0.14	0.97	0.08	-0.05	-0.01	-0.01	-0.02	0.02	-0.12	-0.14	0.04	0.06	-0.02	-0.03	0.00	-0.01	-0.09	-0.17
Heating	0.01	-0.06	-0.03	-0.03	0.03	-0.01	-0.12	-0.01	-0.08	-0.03	0.08	0.95	-0.12	-0.02	-0.33	-0.02	-0.04	0.02	-0.12	-0.10	0.06	-0.01	-0.02	0.10	-0.02	0.04	0.00
Natural lighting	-0.07	0.08	-0.01	0.01	0.02	-0.04	0.01	-0.04	0.00	-0.05	-0.05	-0.12	0.95	-0.24	-0.18	0.10	-0.05	-0.02	-0.07	-0.02	0.03	0.03	0.05	-0.17	0.05	0.05	-0.06
Artificial lighting	-0.03	0.02	-0.02	-0.01	-0.04	0.08	-0.05	-0.01	-0.02	0.00	-0.01	-0.02	-0.24	0.96	-0.21	-0.06	-0.06	-0.06	0.01	-0.08	0.03	0.00	0.03	0.08	-0.08	-0.02	-0.05
Ventilation	0.08	0.00	-0.07	0.01	0.04	-0.04	0.07	0.04	0.10	0.01	-0.01	-0.33	-0.18	-0.21	0.94	-0.14	-0.01	0.06	-0.16	0.01	-0.03	0.01	-0.04	-0.09	0.04	-0.04	-0.07
Noise	-0.04	-0.01	0.09	0.04	-0.07	-0.07	-0.01	-0.08	-0.05	0.02	-0.02	-0.02	0.10	-0.06	-0.14	0.97	-0.05	0.01	-0.05	0.03	-0.03	0.04	-0.03	-0.02	-0.20	-0.14	-0.04
Cleanliness	0.04	0.04	-0.06	-0.04	0.05	0.03	-0.08	0.03	-0.07	-0.04	0.02	-0.04	-0.05	-0.06	-0.01	-0.05	0.95	-0.48	-0.12	-0.12	0.00	0.00	-0.07	0.01	-0.01	0.00	0.00
Decor	0.03	-0.06	0.11	-0.03	0.00	-0.10	-0.05	0.08	0.06	-0.03	-0.12	0.02	-0.02	-0.06	0.06	0.01	-0.48	0.93	-0.27	0.03	-0.03	0.06	-0.07	-0.03	0.05	-0.03	0.01
Overall comfort	-0.17	0.03	-0.06	0.00	-0.04	0.01	0.01	-0.03	-0.02	0.05	-0.14	-0.12	-0.07	0.01	-0.16	-0.05	-0.12	-0.27	0.97	-0.03	0.02	-0.03	-0.05	-0.06	0.06	0.00	-0.15
Physical Security	-0.06	-0.04	0.02	-0.02	-0.05	0.07	-0.07	0.06	0.00	-0.04	0.04	-0.10	-0.02	-0.08	0.01	0.03	-0.12	0.03	-0.03	0.97	-0.18	-0.07	0.00	-0.04	-0.04	0.01	-0.02
Social Interaction	0.03	0.01	0.00	0.00	-0.01	0.07	0.00	-0.11	-0.06	-0.09	0.06	0.06	0.03	0.03	-0.03	-0.03	0.00	-0.03	0.02	-0.18	0.88	-0.56	-0.12	0.04	0.06	0.04	-0.14
Work Interaction	-0.06	0.01	-0.05	0.01	0.01	-0.09	0.03	-0.11	-0.05	0.06	-0.02	-0.01	0.03	0.00	0.01	0.04	0.00	0.06	-0.03	-0.07	-0.56	0.91	-0.08	-0.02	0.01	0.01	-0.11
Creative physical environment	-0.02	-0.03	-0.03	-0.04	-0.04	-0.03	-0.01	0.01	-0.02	-0.01	-0.03	-0.02	0.05	0.03	-0.04	-0.03	-0.07	-0.07	-0.05	0.00	-0.12	-0.08	0.98	-0.21	-0.01	0.04	-0.13
Privacy	-0.01	0.00	0.01	0.04	-0.02	-0.20	0.03	0.00	0.02	-0.06	0.00	0.10	-0.17	0.08	-0.09	-0.02	0.01	-0.03	-0.06	-0.04	0.04	-0.02	-0.21	0.95	-0.31	-0.03	-0.05
Interruptions	-0.01	-0.02	-0.04	-0.03	0.04	-0.06	0.00	0.03	-0.07	0.08	-0.01	-0.02	0.05	-0.08	0.04	-0.20	-0.01	0.05	0.06	-0.04	0.06	0.01	-0.01	-0.31	0.93	-0.33	-0.11
Crowding	0.01	-0.03	-0.04	0.00	-0.03	0.09	-0.10	-0.06	0.01	0.02	-0.09	0.04	0.05	-0.02	-0.04	-0.14	0.00	-0.03	0.00	0.01	0.04	0.01	0.04	-0.03	-0.33	0.96	-0.15
Overall atmosphere	-0.01	-0.02	0.06	-0.01	-0.01	0.05	-0.02	-0.03	0.04	0.00	-0.17	0.00	-0.06	-0.05	-0.07	-0.04	0.00	0.01	-0.15	-0.02	-0.14	-0.11	-0.13	-0.05	-0.11	-0.15	0.98

Appendix F: Correlation matrix for private sector company data set

	Workarea, Desk	Personal storage	General storage	Formal meeting areas	Informal meeting areas	Quiet areas	Circulation space	Position colleagues	Position equipment	Refreshment	Overall office layout	Heating	Natural lighting	Artificial lighting	Ventilation	Noise	Cleanliness	Decor	Overall comfort	Physical Security	Social Interaction	Work Interaction	Creative physical environment	Privacy	Interruptions	Crowding	Overall atmosphere
Workarea, Desk	1.00	0.64	0.38	0.40	0.30	0.39	0.28	0.40	0.20	0.27	0.56	0.38	0.45	0.24	0.41	0.26	0.32	0.38	0.61	0.22	0.35	0.43	0.47	0.58	0.31	0.14	0.56
Personal storage	0.64	1.00	0.59	0.38	0.26	0.32	0.23	0.28	0.17	0.18	0.50	0.37	0.37	0.23	0.35	0.25	0.26	0.32	0.47	0.24	0.26	0.33	0.44	0.53	0.29	0.09	0.44
General storage	0.38	0.59	1.00	0.33	0.28	0.27	0.24	0.24	0.21	0.17	0.39	0.29	0.28	0.21	0.32	0.31	0.28	0.29	0.36	0.21	0.23	0.22	0.35	0.41	0.31	0.11	0.34
Formal meeting areas	0.40	0.38	0.33	1.00	0.40	0.42	0.16	0.27	0.11	0.19	0.34	0.27	0.26	0.11	0.26	0.11	0.19	0.27	0.36	0.08	0.24	0.27	0.34	0.39	0.22	0.06	0.30
Informal meeting areas	0.30	0.26	0.28	0.40	1.00	0.63	0.21	0.20	0.07	0.13	0.28	0.34	0.30	0.06	0.31	0.12	0.19	0.22	0.33	0.09	0.37	0.31	0.40	0.35	0.17	0.03	0.31
Quiet areas	0.39	0.32	0.27	0.42	0.63	1.00	0.29	0.26	0.06	0.10	0.34	0.34	0.42	0.06	0.35	0.11	0.27	0.27	0.43	0.10	0.32	0.35	0.49	0.48	0.22	0.01	0.38
Circulation space	0.28	0.23	0.24	0.16	0.21	0.29	1.00	0.34	0.27	0.31	0.35	0.24	0.31	0.19	0.27	0.13	0.26	0.41	0.36	0.26	0.36	0.32	0.38	0.25	0.18	0.14	0.42
Position colleagues	0.40	0.28	0.24	0.27	0.20	0.26	0.34	1.00	0.42	0.34	0.48	0.38	0.32	0.17	0.32	0.17	0.23	0.28	0.39	0.17	0.39	0.52	0.41	0.33	0.17	0.08	0.51
Position equipment	0.20	0.17	0.21	0.11	0.07	0.06	0.27	0.42	1.00	0.43	0.35	0.28	0.16	0.27	0.20	0.36	0.21	0.14	0.23	0.22	0.30	0.30	0.24	0.20	0.27	0.23	0.37
Refreshment	0.27	0.18	0.17	0.19	0.13	0.10	0.31	0.34	0.43	1.00	0.44	0.36	0.25	0.27	0.30	0.18	0.30	0.30	0.35	0.28	0.31	0.29	0.29	0.21	0.18	0.17	0.40
Overall office layout	0.56	0.50	0.39	0.34	0.28	0.34	0.35	0.48	0.35	0.44	1.00	0.56	0.49	0.32	0.47	0.36	0.39	0.46	0.56	0.29	0.46	0.49	0.51	0.49	0.36	0.17	0.71
Heating	0.38	0.37	0.29	0.27	0.34	0.34	0.24	0.38	0.28	0.36	0.56	1.00	0.54	0.41	0.68	0.36	0.45	0.32	0.53	0.29	0.34	0.36	0.44	0.46	0.30	0.11	0.59
Natural lighting	0.45	0.37	0.28	0.26	0.30	0.42	0.31	0.32	0.16	0.25	0.49	0.54	1.00	0.32	0.55	0.22	0.40	0.40	0.53	0.24	0.38	0.42	0.51	0.47	0.24	0.03	0.53
Artificial lighting	0.24	0.23	0.21	0.11	0.06	0.06	0.19	0.17	0.27	0.27	0.32	0.41	0.32	1.00	0.42	0.42	0.30	0.29	0.34	0.29	0.14	0.11	0.19	0.23	0.32	0.30	0.34
Ventilation	0.41	0.35	0.32	0.26	0.31	0.35	0.27	0.32	0.20	0.30	0.47	0.68	0.55	0.42	1.00	0.34	0.49	0.36	0.52	0.29	0.33	0.37	0.45	0.43	0.33	0.14	0.53
Noise	0.26	0.25	0.31	0.11	0.12	0.11	0.13	0.17	0.36	0.18	0.36	0.36	0.22	0.42	0.34	1.00	0.31	0.16	0.28	0.18	0.18	0.17	0.20	0.27	0.60	0.50	0.35
Cleanliness	0.32	0.26	0.28	0.19	0.19	0.27	0.26	0.23	0.21	0.30	0.39	0.45	0.40	0.30	0.49	0.31	1.00	0.54	0.50	0.34	0.24	0.25	0.30	0.41	0.23	0.12	0.40
Decor	0.38	0.32	0.29	0.27	0.22	0.27	0.41	0.28	0.14	0.30	0.46	0.32	0.40	0.29	0.36	0.16	0.54	1.00	0.58	0.34	0.33	0.29	0.40	0.33	0.16	0.09	0.45
Overall comfort	0.61	0.47	0.36	0.36	0.33	0.43	0.36	0.39	0.23	0.35	0.56	0.53	0.53	0.34	0.52	0.28	0.50	0.58	1.00	0.39	0.37	0.42	0.52	0.54	0.25	0.11	0.66
Physical Security	0.22	0.24	0.21	0.08	0.09	0.10	0.26	0.17	0.22	0.28	0.29	0.29	0.24	0.29	0.29	0.18	0.34	0.34	0.39	1.00	0.23	0.22	0.20	0.27	0.15	0.16	0.32
Social Interaction	0.35	0.26	0.23	0.24	0.37	0.32	0.36	0.39	0.30	0.31	0.46	0.34	0.38	0.14	0.33	0.18	0.24	0.33	0.37	0.23	1.00	0.73	0.50	0.31	0.19	0.06	0.52
Work Interaction	0.43	0.33	0.22	0.27	0.31	0.35	0.32	0.52	0.30	0.29	0.49	0.36	0.42	0.11	0.37	0.17	0.25	0.29	0.42	0.22	0.73	1.00	0.50	0.34	0.19	0.04	0.59
Creative physical environment	0.47	0.44	0.35	0.34	0.40	0.49	0.38	0.41	0.24	0.29	0.51	0.44	0.51	0.19	0.45	0.20	0.30	0.40	0.52	0.20	0.50	0.50	1.00	0.54	0.26	0.06	0.58
Privacy	0.58	0.53	0.41	0.39	0.35	0.48	0.25	0.33	0.20	0.21	0.49	0.46	0.47	0.23	0.43	0.27	0.41	0.33	0.54	0.27	0.31	0.34	0.54	1.00	0.43	0.07	0.53
Interruptions	0.31	0.29	0.31	0.22	0.17	0.22	0.18	0.17	0.27	0.18	0.36	0.30	0.24	0.32	0.33	0.60	0.23	0.16	0.25	0.15	0.19	0.19	0.26	0.43	1.00	0.59	0.39
Crowding	0.14	0.09	0.11	0.06	0.03	0.01	0.14	0.08	0.23	0.17	0.17	0.11	0.03	0.30	0.14	0.50	0.12	0.09	0.11	0.16	0.06	0.04	0.06	0.07	0.59	1.00	0.20
Overall atmosphere	0.56	0.44	0.34	0.30	0.31	0.38	0.42	0.51	0.37	0.40	0.71	0.59	0.53	0.34	0.53	0.35	0.40	0.45	0.66	0.32	0.52	0.59	0.58	0.53	0.39	0.20	1.00

Appendix G: Anti-image correlation matrix for private sector data

	Workarea, Desk	Personal storage	General storage	Formal meeting areas	Informal meeting areas	Quiet areas	Circulation space	Position colleagues	Position equipment	Refreshment	Overall office layout	Heating	Natural lighting	Artificial lighting	Ventilation	Noise	Cleanliness	Decor	Overall comfort	Physical Security	Social Interaction	Work Interaction	Creative physical environment	Privacy	Interruptions	Crowding	Overall atmosphere
Workarea, Desk	0.92	-0.38	0.09	-0.07	-0.01	-0.02	0.01	-0.09	0.04	-0.03	-0.10	0.16	-0.05	-0.01	-0.08	-0.02	0.05	0.01	-0.25	0.08	0.00	-0.06	0.05	-0.20	0.04	-0.08	-0.06
Personal storage	-0.38	0.89	-0.42	-0.08	0.03	0.03	-0.01	0.08	0.02	0.08	-0.13	-0.09	0.00	-0.03	0.06	0.02	0.06	-0.01	0.02	-0.07	0.07	-0.07	-0.09	-0.11	0.00	0.01	0.05
General storage	0.09	-0.42	0.90	-0.08	-0.11	0.04	-0.06	-0.04	-0.06	0.02	-0.03	0.09	0.01	0.01	-0.08	-0.12	-0.05	-0.03	-0.01	-0.02	-0.02	0.07	-0.02	-0.04	-0.06	0.06	0.01
Formal meeting areas	-0.07	-0.08	-0.08	0.95	-0.16	-0.13	0.07	-0.07	0.01	-0.07	-0.04	0.00	0.04	-0.01	0.00	0.08	0.04	-0.07	-0.06	0.08	0.01	-0.02	0.01	-0.07	-0.06	-0.01	0.07
Informal meeting areas	-0.01	0.03	-0.11	-0.16	0.87	-0.47	0.03	0.05	0.04	-0.02	0.04	-0.13	0.05	0.03	-0.01	-0.02	0.04	-0.01	0.01	0.01	-0.19	0.03	-0.03	0.00	0.04	-0.03	0.01
Quiet areas	-0.02	0.03	0.04	-0.13	-0.47	0.89	-0.14	-0.01	0.04	0.11	-0.01	0.01	-0.11	0.09	-0.02	0.03	-0.05	0.05	-0.10	0.05	0.07	-0.05	-0.12	-0.12	-0.06	0.03	0.02
Circulation space	0.01	-0.01	-0.06	0.07	0.03	-0.14	0.94	-0.10	-0.09	-0.09	0.03	0.08	-0.04	-0.01	-0.01	0.07	0.01	-0.19	0.02	-0.07	-0.09	0.04	-0.07	0.05	-0.01	-0.07	-0.11
Position colleagues	-0.09	0.08	-0.04	-0.07	0.05	-0.01	-0.10	0.93	-0.24	-0.03	-0.11	-0.09	0.03	0.02	0.00	0.04	0.03	-0.01	0.00	0.05	0.07	-0.24	-0.05	-0.03	0.08	-0.03	-0.05
Position equipment	0.04	0.02	-0.06	0.01	0.04	0.04	-0.09	-0.24	0.89	-0.27	0.00	-0.02	0.06	-0.08	0.09	-0.19	-0.03	0.10	0.03	-0.05	-0.05	-0.03	-0.01	0.00	-0.03	0.01	-0.06
Refreshment	-0.03	0.08	0.02	-0.07	-0.02	0.11	-0.09	-0.03	-0.27	0.92	-0.17	-0.08	0.02	-0.04	-0.01	0.11	-0.07	0.00	-0.05	-0.08	-0.05	0.02	-0.04	0.05	0.01	-0.06	0.01
Overall office layout	-0.10	-0.13	-0.03	-0.04	0.04	-0.01	0.03	-0.11	0.00	-0.17	0.96	-0.16	-0.04	0.02	0.05	-0.09	0.02	-0.14	0.04	0.00	-0.06	0.00	-0.02	0.01	-0.05	0.04	-0.29
Heating	0.16	-0.09	0.09	0.00	-0.13	0.01	0.08	-0.09	-0.02	-0.08	-0.16	0.92	-0.13	-0.10	-0.39	-0.10	-0.09	0.12	-0.08	-0.02	0.00	0.07	0.01	-0.06	0.05	0.06	-0.15
Natural lighting	-0.05	0.00	0.01	0.04	0.05	-0.11	-0.04	0.03	0.06	0.02	-0.04	-0.13	0.97	-0.11	-0.15	0.02	-0.03	-0.05	-0.05	0.03	-0.03	-0.07	-0.11	-0.06	-0.01	0.07	-0.02
Artificial lighting	-0.01	-0.03	0.01	-0.01	0.03	0.09	-0.01	0.02	-0.08	-0.04	0.02	-0.10	-0.11	0.93	-0.15	-0.17	0.04	-0.11	-0.03	-0.09	0.00	0.10	0.04	0.01	-0.01	-0.10	-0.03
Ventilation	-0.08	0.06	-0.08	0.00	-0.01	-0.02	-0.01	0.00	0.09	-0.01	0.05	-0.39	-0.15	-0.15	0.93	0.00	-0.18	0.03	-0.02	-0.04	0.03	-0.07	-0.09	0.07	-0.10	0.03	-0.01
Noise	-0.02	0.02	-0.12	0.08	-0.02	0.03	0.07	0.04	-0.19	0.11	-0.09	-0.10	0.02	-0.17	0.00	0.88	-0.13	0.08	-0.07	0.04	-0.03	0.01	0.01	0.07	-0.32	-0.20	0.02
Cleanliness	0.05	0.06	-0.05	0.04	0.04	-0.05	0.01	0.03	-0.03	-0.07	0.02	-0.09	-0.03	0.04	-0.18	-0.13	0.92	-0.35	-0.08	-0.08	0.02	-0.02	0.09	-0.18	0.07	-0.02	0.05
Decor	0.01	-0.01	-0.03	-0.07	-0.01	0.05	-0.19	-0.01	0.10	0.00	-0.14	0.12	-0.05	-0.11	0.03	0.08	-0.35	0.90	-0.27	-0.07	-0.08	0.07	-0.08	0.10	0.00	0.00	-0.01
Overall comfort	-0.25	0.02	-0.01	-0.06	0.01	-0.10	0.02	0.00	0.03	-0.05	0.04	-0.08	-0.05	-0.03	-0.02	-0.07	-0.08	-0.27	0.95	-0.16	0.06	0.00	-0.05	-0.05	0.09	0.03	-0.24
Physical Security	0.08	-0.07	-0.02	0.08	0.01	0.05	-0.07	0.05	-0.05	-0.08	0.00	-0.02	0.03	-0.09	-0.04	0.04	-0.08	-0.07	-0.16	0.92	-0.05	-0.04	0.08	-0.12	0.07	-0.11	0.01
Social Interaction	0.00	0.07	-0.02	0.01	-0.19	0.07	-0.09	0.07	-0.05	-0.05	-0.06	0.00	-0.03	0.00	0.03	-0.03	0.02	-0.08	0.06	-0.05	0.88	-0.57	-0.15	0.02	0.00	0.01	-0.02
Work Interaction	-0.06	-0.07	0.07	-0.02	0.03	-0.05	0.04	-0.24	-0.03	0.02	0.00	0.07	-0.07	0.10	-0.07	0.01	-0.02	0.07	0.00	-0.04	-0.57	0.88	-0.03	0.08	-0.01	0.06	-0.21
Creative physical environment	0.05	-0.09	-0.02	0.01	-0.03	-0.12	-0.07	-0.05	-0.01	-0.04	-0.02	0.01	-0.11	0.04	-0.09	0.01	0.09	-0.08	-0.05	0.08	-0.15	-0.03	0.96	-0.20	0.02	0.00	-0.10
Privacy	-0.20	-0.11	-0.04	-0.07	0.00	-0.12	0.05	-0.03	0.00	0.05	0.01	-0.06	-0.06	0.01	0.07	0.07	-0.18	0.10	-0.05	-0.12	0.02	0.08	-0.20	0.92	-0.31	0.20	-0.08
Interruptions	0.04	0.00	-0.06	-0.06	0.04	-0.06	-0.01	0.08	-0.03	0.01	-0.05	0.05	-0.01	-0.01	-0.10	-0.32	0.07	0.00	0.09	0.07	0.00	-0.01	0.02	-0.31	0.83	-0.48	-0.08
Crowding	-0.08	0.01	0.06	-0.01	-0.03	0.03	-0.07	-0.03	0.01	-0.06	0.04	0.06	0.07	-0.10	0.03	-0.20	-0.02	0.00	0.03	-0.11	0.01	0.06	0.00	0.20	-0.48	0.73	-0.06
Overall atmosphere	-0.06	0.05	0.01	0.07	0.01	0.02	-0.11	-0.05	-0.06	0.01	-0.29	-0.15	-0.02	-0.03	-0.01	0.02	0.05	-0.01	-0.24	0.01	-0.02	-0.21	-0.10	-0.08	-0.08	-0.06	0.95

Appendix H: Frequency tables for combined data set

Type of Office

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid		3	.7	.7	.7
		Cellular	80	19.0	19.0	19.7
		Open Plan	339	80.3	80.3	100.0
		Total	422	100.0	100.0	
Public Sector	Valid		13	1.3	1.3	1.3
		Cellular	178	17.9	17.9	19.2
		Open Plan	805	80.8	80.8	100.0
		Total	996	100.0	100.0	

Dedicated Desk

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid		4	.9	.9	.9
		Yes	406	96.2	96.2	97.2
		No	12	2.8	2.8	100.0
		Total	422	100.0	100.0	
Public Sector	Valid		9	.9	.9	.9
		Yes	944	94.8	94.8	95.7
		No	43	4.3	4.3	100.0
		Total	996	100.0	100.0	

Gender

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid		18	4.3	4.3	4.3
		Male	221	52.4	52.4	56.6
		Female	183	43.4	43.4	100.0
		Total	422	100.0	100.0	
Public Sector	Valid		6	.6	.6	.6
		Male	403	40.5	40.5	41.1
		Female	587	58.9	58.9	100.0
		Total	996	100.0	100.0	

Age of Respondent

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	<25	29	6.9	7.0	7.0
		25-35	199	47.2	47.7	54.7
		36-45	131	31.0	31.4	86.1
		46-55	56	13.3	13.4	99.5
		>55	2	.5	.5	100.0
		Total	417	98.8	100.0	
	Missing	System	5	1.2		
	Total		422	100.0		
Public Sector	Valid	<25	43	4.3	4.3	4.3
		25-35	227	22.8	23.0	27.3
		36-45	294	29.5	29.7	57.0
		46-55	324	32.5	32.8	89.8
		>55	101	10.1	10.2	100.0
		Total	989	99.3	100.0	
	Missing	System	7	.7		
	Total		996	100.0		

Time with Colleagues

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	0-20	42	10.0	10.1	10.1
		21-40	99	23.5	23.8	33.9
		41-60	117	27.7	28.1	62.0
		61-80	89	21.1	21.4	83.4
		81-100	69	16.4	16.6	100.0
		Total	416	98.6	100.0	
	Missing	System	6	1.4		
	Total		422	100.0		
Public Sector	Valid	0-20	142	14.3	14.4	14.4
		21-40	226	22.7	22.9	37.4
		41-60	233	23.4	23.7	61.0
		61-80	176	17.7	17.9	78.9
		81-100	208	20.9	21.1	100.0
		Total	985	98.9	100.0	
	Missing	System	11	1.1		
	Total		996	100.0		

Time in the Office

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	0-20	2	.5	.5	.5
		21-40	15	3.6	3.6	4.1
		41-60	48	11.4	11.5	15.6
		61-80	86	20.4	20.6	36.1
		81-100	267	63.3	63.9	100.0
		Total	418	99.1	100.0	
	Missing	System	4	.9		
	Total		422	100.0		
Public Sector	Valid	0-20	18	1.8	1.8	1.8
		21-40	79	7.9	8.0	9.8
		41-60	175	17.6	17.6	27.4
		61-80	158	15.9	15.9	43.3
		81-100	563	56.5	56.7	100.0
		Total	993	99.7	100.0	
	Missing	System	3	.3		
	Total		996	100.0		

Flexibility in how, when and where you work

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Low	104	24.6	24.8	24.8
		Low	90	21.3	21.5	46.3
		Average	128	30.3	30.5	76.8
		High	73	17.3	17.4	94.3
		Very High	24	5.7	5.7	100.0
		Total	419	99.3	100.0	
	Missing	System	3	.7		
	Total		422	100.0		
Public Sector	Valid	Very Low	164	16.5	16.5	16.5
		Low	222	22.3	22.4	38.9
		Average	334	33.5	33.6	72.5
		High	238	23.9	24.0	96.5
		Very High	35	3.5	3.5	100.0
		Total	993	99.7	100.0	
	Missing	System	3	.3		
	Total		996	100.0		

Variety of tasks undertaken in the office

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Low	12	2.8	2.9	2.9
		Low	23	5.5	5.6	8.6
		Average	183	43.4	44.9	53.4
		High	141	33.4	34.6	88.0
		Very High	49	11.6	12.0	100.0
		Total	408	96.7	100.0	
	Missing	System	14	3.3		
	Total		422	100.0		
Public Sector	Valid	Very Low	17	1.7	1.7	1.7
		Low	57	5.7	5.8	7.5
		Average	434	43.6	43.9	51.4
		High	369	37.0	37.3	88.7
		Very High	112	11.2	11.3	100.0
		Total	989	99.3	100.0	
	Missing	System	7	.7		
	Total		996	100.0		

Interaction-Time

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Low	258	61.1	62.0	62.0
		High	158	37.4	38.0	100.0
		Total	416	98.6	100.0	
	Missing	System	6	1.4		
	Total		422	100.0		
Public Sector	Valid	Low	601	60.3	61.0	61.0
		High	384	38.6	39.0	100.0
		Total	985	98.9	100.0	
	Missing	System	11	1.1		
	Total		996	100.0		

Autonomy

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Low	322	76.3	76.8	76.8
		High	97	23.0	23.2	100.0
		Total	419	99.3	100.0	
	Missing	System	3	.7		
	Total		422	100.0		
Public Sector	Valid	Low	720	72.3	72.5	72.5
		High	273	27.4	27.5	100.0
		Total	993	99.7	100.0	
	Missing	System	3	.3		
	Total		996	100.0		

Work Patterns

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Individual Process Work	188	44.5	45.2	45.2
		Group Process Work	132	31.3	31.7	76.9
		Concentrated Study Work	70	16.6	16.8	93.8
		Transactional Knowledge Work	26	6.2	6.3	100.0
		Total	416	98.6	100.0	
	Missing	System	6	1.4		
	Total		422	100.0		
Public Sector	Valid	Individual Process Work	418	42.0	42.5	42.5
		Group Process Work	293	29.4	29.8	72.3
		Concentrated Study Work	182	18.3	18.5	90.8
		Transactional Knowledge Work	90	9.0	9.2	100.0
		Total	983	98.7	100.0	
	Missing	System	13	1.3		
	Total		996	100.0		

Workarea, Desk

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	4	.9	1.0	1.0
		Negative	26	6.2	6.3	7.2
		Neutral	104	24.6	25.1	32.3
		Positive	183	43.4	44.1	76.4
		Very Positive	98	23.2	23.6	100.0
		Total	415	98.3	100.0	
	Missing	System	7	1.7		
	Total		422	100.0		
Public Sector	Valid	Very Negative	78	7.8	7.9	7.9
		Negative	215	21.6	21.9	29.8
		Neutral	347	34.8	35.3	65.1
		Positive	283	28.4	28.8	93.9
		Very Positive	60	6.0	6.1	100.0
		Total	983	98.7	100.0	
	Missing	System	13	1.3		
	Total		996	100.0		

Personal Storage

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	10	2.4	2.4	2.4
		Negative	54	12.8	12.9	15.3
		Neutral	151	35.8	36.2	51.6
		Positive	150	35.5	36.0	87.5
		Very Positive	52	12.3	12.5	100.0
		Total	417	98.8	100.0	
	Missing	System	5	1.2		
	Total		422	100.0		
Public Sector	Valid	Very Negative	142	14.3	14.3	14.3
		Negative	251	25.2	25.4	39.7
		Neutral	362	36.3	36.6	76.3
		Positive	199	20.0	20.1	96.4
		Very Positive	36	3.6	3.6	100.0
		Total	990	99.4	100.0	
	Missing	System	6	.6		
	Total		996	100.0		

General Storage

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	20	4.7	4.8	4.8
		Negative	70	16.6	16.8	21.6
		Neutral	206	48.8	49.5	71.2
		Positive	96	22.7	23.1	94.2
		Very Positive	24	5.7	5.8	100.0
		Total	416	98.6	100.0	
	Missing	System	6	1.4		
	Total		422	100.0		
Public Sector	Valid	Very Negative	162	16.3	16.4	16.4
		Negative	293	29.4	29.7	46.1
		Neutral	366	36.7	37.0	83.1
		Positive	150	15.1	15.2	98.3
		Very Positive	17	1.7	1.7	100.0
		Total	988	99.2	100.0	
	Missing	System	8	.8		
	Total		996	100.0		

Formal Meeting Area

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	8	1.9	1.9	1.9
		Negative	48	11.4	11.6	13.5
		Neutral	119	28.2	28.7	42.2
		Positive	197	46.7	47.5	89.6
		Very Positive	43	10.2	10.4	100.0
		Total	415	98.3	100.0	
	Missing	System	7	1.7		
	Total		422	100.0		
Public Sector	Valid	Very Negative	191	19.2	19.4	19.4
		Negative	253	25.4	25.7	45.1
		Neutral	334	33.5	33.9	79.1
		Positive	181	18.2	18.4	97.5
		Very Positive	25	2.5	2.5	100.0
		Total	984	98.8	100.0	
	Missing	System	12	1.2		
	Total		996	100.0		

Informal Meeting Area

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	19	4.5	4.6	4.6
		Negative	65	15.4	15.7	20.3
		Neutral	152	36.0	36.7	57.0
		Positive	145	34.4	35.0	92.0
		Very Positive	33	7.8	8.0	100.0
		Total	414	98.1	100.0	
	Missing	System	8	1.9		
	Total		422	100.0		
Public Sector	Valid	Very Negative	228	22.9	23.2	23.2
		Negative	293	29.4	29.8	53.0
		Neutral	343	34.4	34.9	87.9
		Positive	105	10.5	10.7	98.6
		Very Positive	14	1.4	1.4	100.0
		Total	983	98.7	100.0	
	Missing	System	13	1.3		
	Total		996	100.0		

Quiet Areas

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	38	9.0	9.2	9.2
		Negative	74	17.5	18.0	27.2
		Neutral	155	36.7	37.6	64.8
		Positive	93	22.0	22.6	87.4
		Very Positive	52	12.3	12.6	100.0
		Total	412	97.6	100.0	
	Missing	System	10	2.4		
	Total		422	100.0		
Public Sector	Valid	Very Negative	361	36.2	37.4	37.4
		Negative	260	26.1	26.9	64.3
		Neutral	234	23.5	24.2	88.5
		Positive	86	8.6	8.9	97.4
		Very Positive	25	2.5	2.6	100.0
		Total	966	97.0	100.0	
	Missing	System	30	3.0		
	Total		996	100.0		

Circulation Space

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	8	1.9	2.0	2.0
		Negative	26	6.2	6.3	8.3
		Neutral	233	55.2	56.8	65.1
		Positive	125	29.6	30.5	95.6
		Very Positive	18	4.3	4.4	100.0
		Total	410	97.2	100.0	
	Missing	System	12	2.8		
	Total		422	100.0		
Public Sector	Valid	Very Negative	134	13.5	13.6	13.6
		Negative	257	25.8	26.0	39.6
		Neutral	446	44.8	45.2	84.8
		Positive	129	13.0	13.1	97.9
		Very Positive	21	2.1	2.1	100.0
		Total	987	99.1	100.0	
	Missing	System	9	.9		
	Total		996	100.0		

Position Relative to Colleagues

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	11	2.6	2.7	2.7
		Negative	37	8.8	9.0	11.7
		Neutral	91	21.6	22.1	33.7
		Positive	217	51.4	52.7	86.4
		Very Positive	56	13.3	13.6	100.0
		Total	412	97.6	100.0	
	Missing	System	10	2.4		
	Total		422	100.0		
Public Sector	Valid	Very Negative	84	8.4	8.5	8.5
		Negative	176	17.7	17.9	26.4
		Neutral	342	34.3	34.8	61.2
		Positive	324	32.5	33.0	94.2
		Very Positive	57	5.7	5.8	100.0
		Total	983	98.7	100.0	
	Missing	System	13	1.3		
	Total		996	100.0		

Position Relative to Equipment

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	25	5.9	6.0	6.0
		Negative	29	6.9	7.0	13.0
		Neutral	180	42.7	43.5	56.5
		Positive	156	37.0	37.7	94.2
		Very Positive	24	5.7	5.8	100.0
		Total	414	98.1	100.0	
	Missing	System	8	1.9		
	Total		422	100.0		
Public Sector	Valid	Very Negative	102	10.2	10.4	10.4
		Negative	197	19.8	20.0	30.4
		Neutral	425	42.7	43.1	73.5
		Positive	228	22.9	23.1	96.6
		Very Positive	33	3.3	3.4	100.0
		Total	985	98.9	100.0	
	Missing	System	11	1.1		
	Total		996	100.0		

Refreshments

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	6	1.4	1.4	1.4
		Negative	17	4.0	4.1	5.5
		Neutral	163	38.6	39.3	44.8
		Positive	193	45.7	46.5	91.3
		Very Positive	36	8.5	8.7	100.0
		Total	415	98.3	100.0	
	Missing	System	7	1.7		
	Total		422	100.0		
Public Sector	Valid	Very Negative	100	10.0	10.1	10.1
		Negative	153	15.4	15.5	25.6
		Neutral	438	44.0	44.3	69.9
		Positive	256	25.7	25.9	95.9
		Very Positive	41	4.1	4.1	100.0
		Total	988	99.2	100.0	
	Missing	System	8	.8		
	Total		996	100.0		

Overall Office Layout

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	14	3.3	3.4	3.4
		Negative	55	13.0	13.3	16.7
		Neutral	133	31.5	32.2	48.9
		Positive	179	42.4	43.3	92.3
		Very Positive	32	7.6	7.7	100.0
		Total	413	97.9	100.0	
	Missing	System	9	2.1		
	Total		422	100.0		
Public Sector	Valid	Very Negative	215	21.6	21.7	21.7
		Negative	288	28.9	29.1	50.8
		Neutral	279	28.0	28.2	78.9
		Positive	178	17.9	18.0	96.9
		Very Positive	31	3.1	3.1	100.0
		Total	991	99.5	100.0	
	Missing	System	5	.5		
	Total		996	100.0		

Heating

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	23	5.5	5.6	5.6
		Negative	56	13.3	13.5	19.1
		Neutral	148	35.1	35.7	54.8
		Positive	160	37.9	38.6	93.5
		Very Positive	27	6.4	6.5	100.0
		Total	414	98.1	100.0	
	Missing	System	8	1.9		
	Total		422	100.0		
Public Sector	Valid	Very Negative	176	17.7	17.8	17.8
		Negative	339	34.0	34.3	52.2
		Neutral	316	31.7	32.0	84.2
		Positive	138	13.9	14.0	98.2
		Very Positive	18	1.8	1.8	100.0
		Total	987	99.1	100.0	
	Missing	System	9	.9		
	Total		996	100.0		

Natural Light

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	33	7.8	8.0	8.0
		Negative	48	11.4	11.6	19.6
		Neutral	106	25.1	25.6	45.2
		Positive	161	38.2	38.9	84.1
		Very Positive	66	15.6	15.9	100.0
		Total	414	98.1	100.0	
	Missing	System	8	1.9		
	Total		422	100.0		
Public Sector	Valid	Very Negative	216	21.7	22.0	22.0
		Negative	199	20.0	20.2	42.2
		Neutral	253	25.4	25.7	67.9
		Positive	266	26.7	27.0	94.9
		Very Positive	50	5.0	5.1	100.0
		Total	984	98.8	100.0	
	Missing	System	12	1.2		
	Total		996	100.0		

Artificial Light

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	28	6.6	6.8	6.8
		Negative	103	24.4	24.9	31.7
		Neutral	167	39.6	40.4	72.2
		Positive	101	23.9	24.5	96.6
		Very Positive	14	3.3	3.4	100.0
		Total	413	97.9	100.0	
	Missing	System	9	2.1		
	Total		422	100.0		
Public Sector	Valid	Very Negative	177	17.8	17.9	17.9
		Negative	291	29.2	29.5	47.4
		Neutral	387	38.9	39.2	86.5
		Positive	113	11.3	11.4	98.0
		Very Positive	20	2.0	2.0	100.0
		Total	988	99.2	100.0	
	Missing	System	8	.8		
	Total		996	100.0		

Ventilation

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	31	7.3	7.5	7.5
		Negative	84	19.9	20.4	28.0
		Neutral	127	30.1	30.9	58.9
		Positive	137	32.5	33.3	92.2
		Very Positive	32	7.6	7.8	100.0
		Total	411	97.4	100.0	
	Missing	System	11	2.6		
	Total		422	100.0		
Public Sector	Valid	Very Negative	283	28.4	28.6	28.6
		Negative	348	34.9	35.2	63.9
		Neutral	208	20.9	21.1	84.9
		Positive	119	11.9	12.0	97.0
		Very Positive	30	3.0	3.0	100.0
		Total	988	99.2	100.0	
	Missing	System	8	.8		
	Total		996	100.0		

Noise

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	35	8.3	8.5	8.5
		Negative	92	21.8	22.3	30.8
		Neutral	158	37.4	38.3	69.2
		Positive	96	22.7	23.3	92.5
		Very Positive	31	7.3	7.5	100.0
		Total	412	97.6	100.0	
	Missing	System	10	2.4		
	Total		422	100.0		
Public Sector	Valid	Very Negative	237	23.8	24.0	24.0
		Negative	306	30.7	30.9	54.9
		Neutral	334	33.5	33.8	88.7
		Positive	84	8.4	8.5	97.2
		Very Positive	28	2.8	2.8	100.0
		Total	989	99.3	100.0	
	Missing	System	7	.7		
	Total		996	100.0		

Cleanliness

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	9	2.1	2.2	2.2
		Negative	26	6.2	6.3	8.5
		Neutral	139	32.9	33.7	42.1
		Positive	189	44.8	45.8	87.9
		Very Positive	50	11.8	12.1	100.0
		Total	413	97.9	100.0	
	Missing	System	9	2.1		
	Total		422	100.0		
Public Sector	Valid	Very Negative	188	18.9	19.0	19.0
		Negative	237	23.8	23.9	42.9
		Neutral	379	38.1	38.2	81.1
		Positive	152	15.3	15.3	96.5
		Very Positive	35	3.5	3.5	100.0
		Total	991	99.5	100.0	
	Missing	System	5	.5		
	Total		996	100.0		

Decor

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	7	1.7	1.7	1.7
		Negative	36	8.5	8.7	10.4
		Neutral	201	47.6	48.8	59.2
		Positive	135	32.0	32.8	92.0
		Very Positive	33	7.8	8.0	100.0
		Total	412	97.6	100.0	
	Missing	System	10	2.4		
	Total		422	100.0		
Public Sector	Valid	Very Negative	314	31.5	31.7	31.7
		Negative	223	22.4	22.5	54.2
		Neutral	327	32.8	33.0	87.2
		Positive	108	10.8	10.9	98.1
		Very Positive	19	1.9	1.9	100.0
		Total	991	99.5	100.0	
	Missing	System	5	.5		
	Total		996	100.0		

Overall Comfort

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	5	1.2	1.2	1.2
		Negative	35	8.3	8.5	9.7
		Neutral	125	29.6	30.3	40.0
		Positive	184	43.6	44.6	84.5
		Very Positive	64	15.2	15.5	100.0
		Total	413	97.9	100.0	
	Missing	System	9	2.1		
	Total		422	100.0		
Public Sector	Valid	Very Negative	199	20.0	20.1	20.1
		Negative	268	26.9	27.0	47.1
		Neutral	335	33.6	33.8	80.8
		Positive	161	16.2	16.2	97.1
		Very Positive	29	2.9	2.9	100.0
		Total	992	99.6	100.0	
	Missing	System	4	.4		
	Total		996	100.0		

Physical Security

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	1	.2	.2	.2
		Negative	3	.7	.7	1.0
		Neutral	159	37.7	38.5	39.5
		Positive	203	48.1	49.2	88.6
		Very Positive	47	11.1	11.4	100.0
		Total	413	97.9	100.0	
	Missing	System	9	2.1		
	Total		422	100.0		
Public Sector	Valid	Very Negative	50	5.0	5.1	5.1
		Negative	102	10.2	10.4	15.5
		Neutral	532	53.4	54.1	69.6
		Positive	258	25.9	26.2	95.8
		Very Positive	41	4.1	4.2	100.0
		Total	983	98.7	100.0	
	Missing	System	13	1.3		
	Total		996	100.0		

Social Interaction

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	6	1.4	1.5	1.5
		Negative	33	7.8	8.0	9.4
		Neutral	113	26.8	27.4	36.8
		Positive	211	50.0	51.1	87.9
		Very Positive	50	11.8	12.1	100.0
		Total	413	97.9	100.0	
	Missing	System	9	2.1		
	Total		422	100.0		
Public Sector	Valid	Very Negative	34	3.4	3.5	3.5
		Negative	138	13.9	14.0	17.5
		Neutral	373	37.4	37.9	55.3
		Positive	385	38.7	39.1	94.4
		Very Positive	55	5.5	5.6	100.0
		Total	985	98.9	100.0	
	Missing	System	11	1.1		
	Total		996	100.0		

Work Interaction

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	6	1.4	1.5	1.5
		Negative	11	2.6	2.7	4.1
		Neutral	95	22.5	23.1	27.2
		Positive	234	55.5	56.8	84.0
		Very Positive	66	15.6	16.0	100.0
		Total	412	97.6	100.0	
	Missing	System	10	2.4		
	Total		422	100.0		
Public Sector	Valid	Very Negative	28	2.8	2.8	2.8
		Negative	143	14.4	14.5	17.3
		Neutral	349	35.0	35.3	52.6
		Positive	407	40.9	41.2	93.8
		Very Positive	61	6.1	6.2	100.0
		Total	988	99.2	100.0	
	Missing	System	8	.8		
	Total		996	100.0		

Creative Physical Environment

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	25	5.9	6.1	6.1
		Negative	61	14.5	14.9	21.0
		Neutral	186	44.1	45.5	66.5
		Positive	112	26.5	27.4	93.9
		Very Positive	25	5.9	6.1	100.0
		Total	409	96.9	100.0	
	Missing	System	13	3.1		
	Total		422	100.0		
Public Sector	Valid	Very Negative	156	15.7	16.3	16.3
		Negative	262	26.3	27.3	43.5
		Neutral	413	41.5	43.0	86.6
		Positive	110	11.0	11.5	98.0
		Very Positive	19	1.9	2.0	100.0
		Total	960	96.4	100.0	
	Missing	System	36	3.6		
	Total		996	100.0		

Privacy

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	43	10.2	10.4	10.4
		Negative	107	25.4	25.9	36.3
		Neutral	128	30.3	31.0	67.3
		Positive	99	23.5	24.0	91.3
		Very Positive	36	8.5	8.7	100.0
		Total	413	97.9	100.0	
	Missing	System	9	2.1		
	Total		422	100.0		
Public Sector	Valid	Very Negative	295	29.6	30.2	30.2
		Negative	339	34.0	34.7	64.8
		Neutral	215	21.6	22.0	86.8
		Positive	98	9.8	10.0	96.8
		Very Positive	31	3.1	3.2	100.0
		Total	978	98.2	100.0	
	Missing	System	18	1.8		
	Total		996	100.0		

Interruptions

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	41	9.7	9.9	9.9
		Negative	167	39.6	40.3	50.2
		Neutral	134	31.8	32.4	82.6
		Positive	59	14.0	14.3	96.9
		Very Positive	13	3.1	3.1	100.0
		Total	414	98.1	100.0	
	Missing	System	8	1.9		
	Total		422	100.0		
Public Sector	Valid	Very Negative	314	31.5	31.7	31.7
		Negative	404	40.6	40.8	72.5
		Neutral	205	20.6	20.7	93.2
		Positive	50	5.0	5.1	98.3
		Very Positive	17	1.7	1.7	100.0
		Total	990	99.4	100.0	
	Missing	System	6	.6		
	Total		996	100.0		

Crowding

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	48	11.4	11.7	11.7
		Negative	99	23.5	24.0	35.7
		Neutral	186	44.1	45.1	80.8
		Positive	56	13.3	13.6	94.4
		Very Positive	23	5.5	5.6	100.0
		Total	412	97.6	100.0	
	Missing	System	10	2.4		
	Total		422	100.0		
Public Sector	Valid	Very Negative	255	25.6	25.8	25.8
		Negative	322	32.3	32.6	58.4
		Neutral	328	32.9	33.2	91.6
		Positive	60	6.0	6.1	97.7
		Very Positive	23	2.3	2.3	100.0
		Total	988	99.2	100.0	
	Missing	System	8	.8		
	Total		996	100.0		

Overall Atmosphere

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Very Negative	12	2.8	2.9	2.9
		Negative	29	6.9	7.1	10.0
		Neutral	125	29.6	30.6	40.7
		Positive	196	46.4	48.0	88.7
		Very Positive	46	10.9	11.3	100.0
		Total	408	96.7	100.0	
	Missing	System	14	3.3		
	Total		422	100.0		
Public Sector	Valid	Very Negative	163	16.4	16.5	16.5
		Negative	274	27.5	27.7	44.2
		Neutral	328	32.9	33.2	77.4
		Positive	188	18.9	19.0	96.5
		Very Positive	35	3.5	3.5	100.0
		Total	988	99.2	100.0	
	Missing	System	8	.8		
	Total		996	100.0		

Overall Importance

Type of Sector			Frequency	Percent	Valid Percent	Cumulative Percent
Private Sector	Valid	Low	8	1.9	1.9	1.9
		Average	69	16.4	16.6	18.5
		High	245	58.1	58.9	77.4
		Very High	94	22.3	22.6	100.0
		Total	416	98.6	100.0	
	Missing	System	6	1.4		
	Total		422	100.0		
Public Sector	Valid	Very Low	10	1.0	1.0	1.0
		Low	37	3.7	3.8	4.8
		Average	212	21.3	21.5	26.3
		High	460	46.2	46.7	72.9
		Very High	267	26.8	27.1	100.0
		Total	986	99.0	100.0	
	Missing	System	10	1.0		
	Total		996	100.0		

Appendix J: Chi-squared results

Type of Sector * Ways of Working

Crosstab

% within Ways of Working

		Ways of Working				
		Individual Process Work	Group Process Work	Concentrated Study Work	Transactional Knowledge Work	Total
Type of Sector	Private Sector	31.0%	31.1%	27.8%	22.4%	29.7%
	Public Sector	69.0%	68.9%	72.2%	77.6%	70.3%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.276[a]	3	.233
Likelihood Ratio	4.442	3	.218
N of Valid Cases	1399		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 34.49.

Type of Office * Ways of Working

Crosstab

% within Ways of Working

		Ways of Working				
		Individual Process Work	Group Process Work	Concentrated Study Work	Transactional Knowledge Work	Total
Type of Office	Cellular	16.0%	18.1%	23.4%	19.8%	18.3%
	Open Plan	82.7%	81.2%	75.8%	79.3%	80.7%
		1.3%	.7%	.8%	.9%	1.0%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.698[a]	6	.261
Likelihood Ratio	7.486	6	.278
N of Valid Cases	1399		

a. 3 cells (25.0%) have expected count less than 5. The minimum expected count is 1.16.

Dedicated Desk * Ways of Working

Crosstab

% within Ways of Working

		Ways of Working				
		Individual Process Work	Group Process Work	Concentrated Study Work	Transactional Knowledge Work	Total
Dedicated Desk	Yes	95.5%	97.4%	91.3%	95.7%	95.4%
	No	3.8%	2.1%	7.9%	1.7%	3.9%
		.7%	.5%	.8%	2.6%	.8%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	21.644[a]	6	.001
Likelihood Ratio	18.395	6	.005
N of Valid Cases	1399		

a. 5 cells (41.7%) have expected count less than 5. The minimum expected count is .91.

Gender * Ways of Working

Crosstab

% within Ways of Working

		Ways of Working				
		Individual Process Work	Group Process Work	Concentrated Study Work	Transactional Knowledge Work	Total
Gender	Male	43.6%	32.9%	60.7%	53.4%	44.2%
	Female	54.5%	65.6%	38.1%	44.0%	54.0%
		2.0%	1.4%	1.2%	2.6%	1.7%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	56.049[a]	6	.000
Likelihood Ratio	56.311	6	.000
N of Valid Cases	1399		

a. 2 cells (16.7%) have expected count less than 5. The minimum expected count is 1.99.

Age of Respondent * Ways of Working

Crosstab

% within Ways of Working

		Ways of Working				
		Individual Process Work	Group Process Work	Concentrated Study Work	Transactional Knowledge Work	Total
Age of Respondent	<25	5.3%	5.5%	4.0%	5.2%	5.1%
	25-35	31.9%	30.0%	30.0%	24.3%	30.4%
	36-45	30.7%	28.6%	30.0%	33.9%	30.2%
	46-55	24.8%	29.5%	28.4%	27.0%	27.0%
	>55	7.3%	6.4%	7.6%	9.6%	7.3%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.157[a]	12	.847
Likelihood Ratio	7.228	12	.842
Linear-by-Linear Association	2.604	1	.107
N of Valid Cases	1387		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.89.

Time in the Office * Ways of Working

Crosstab

% within Ways of Working

		Ways of Working				
		Individual Process Work	Group Process Work	Concentrated Study Work	Transactional Knowledge Work	Total
Time in the Office	0-20	1.5%	.2%	3.2%	1.7%	1.4%
	21-40	6.9%	2.6%	14.7%	3.4%	6.7%
	41-60	16.0%	4.2%	31.9%	22.4%	15.8%
	61-80	16.2%	13.2%	24.7%	22.4%	17.3%
	81-100	59.4%	79.7%	25.5%	50.0%	58.7%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	221.151[a]	12	.000
Likelihood Ratio	233.697	12	.000
Linear-by-Linear Association	27.993	1	.000
N of Valid Cases	1397		

a. 2 cells (10.0%) have expected count less than 5. The minimum expected count is 1.66.

Variety of tasks undertaken in the office * Ways of Working

Crosstab

% within Ways of Working

		Ways of Working				
		Individual Process Work	Group Process Work	Concentrated Study Work	Transactional Knowledge Work	Total
Variety of tasks undertaken in the office	Very Low	2.3%	2.9%	1.2%		2.1%
	Low	8.9%	3.8%	3.6%	.9%	5.7%
	Average	48.2%	46.6%	39.8%	23.3%	44.1%
	High	32.4%	33.3%	45.0%	52.6%	36.6%
	Very High	8.2%	13.5%	10.4%	23.3%	11.5%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	78.270[a]	12	.000
Likelihood Ratio	81.102	12	.000
Linear-by-Linear Association	53.647	1	.000
N of Valid Cases	1382		

a. 1 cells (5.0%) have expected count less than 5. The minimum expected count is 2.43.

Overall Importance * Ways of Working

Crosstab

% within Ways of Working

		Ways of Working				
		Individual Process Work	Group Process Work	Concentrated Study Work	Transactional Knowledge Work	Total
Overall Importance	Very Low	.5%	.9%	.4%	.9%	.6%
	Low	2.2%	4.0%	4.0%	3.5%	3.2%
	Average	19.4%	18.0%	23.8%	23.7%	20.1%
	High	52.4%	46.7%	51.2%	50.9%	50.3%
	Very High	25.5%	30.3%	20.6%	21.1%	25.7%
Total		100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.677[a]	12	.162
Likelihood Ratio	16.755	12	.159
Linear-by-Linear Association	4.792	1	.029
N of Valid Cases	1385		

a. 5 cells (25.0%) have expected count less than 5. The minimum expected count is .74.

xxx Bank workplace evaluation

If Price and Barry Haynes

Facilities Management Graduate Centre, Sheffield Hallam University, Unit 7 Science Park, Sheffield S1 1WB[43]

Summary

FMGC were commissioned to use a recently validated survey instrument to examine occupiers' perspectives of the influence of their office environment on their productivity in three business units located in xxx's HQ premises.

The survey was carried out blind, that is we had not seen two of the office designs concerned, though we were aware that one was a relatively new prototype incorporating many modern design ideas and some innovative protocols for flexible working. It was also used to gauge respondents' attitudes to the possibility of extended home or remote working.

There is strong overall support for the proposition we have identified in other research. Design features, which encourage interaction, are seen as having the most positive influence on perceived productivity whereas those, which are distracting, are rated most negatively. There is of course a conundrum here.

The 'Property' office is more positively rated in terms of all the influences on interaction.

It is however rated as negatively as the 'Breakout' office in terms of the perceived distraction, and more negatively than the highest scoring 'flexible' offices we have examined with the same instrument.

We speculate that a culture of having to be seen in the office and or certain individuals feeling over exposed to distraction, or less able to move work location as needed may apply. The responses to the questions concerning greater opportunity to work away

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from the office support this inference, but those issues require following up by the workplace management team.

Introduction

Understanding of how to evaluate and compare office buildings in terms the impact they have on occupiers business performance remains, in general, poor (Haynes *et al.*, 2001). FMGC have developed and statistically validated (Haynes and Price, 2002; in press) a survey instrument, which asks respondents to evaluate the perceived impact of a number of variables on their productivity. This approach does of course assume that personal evaluations of productivity are broadly accurate. While that assumption cannot be independently verified we have observed statistically significant differences between different groups in different offices, and between populations with different profiles on various standard psychological tests (Myers Briggs, Belbin, Kolb), which provides faith in the data.

The survey reported here was commissioned to assess three groups in xxx's head office at Address, City and in particular to see whether any differences could be established for the property unit who have recently moved to a new, flexible, workplace without, in the main, dedicated desks. Apart from a brief visit to that workplace by IP in May 2003 no prior survey was undertaken or floor plans accessed. The intention was that this survey should, so far as possible, constitute a blind test.

An online survey was open from September 24 to October 24 2003, attracting the following responses, all of which would be considered a very favourable return compared to other surveys of this kind

	Sent	Replies	Percentage
Breakout	33	21	64%
Property	30	18	60%
Sourcing	17	11	65%

Despite the relatively small sample the results do show a reasonably high level of reliability with a Cronbach's Alpha value of 0.86 (values above 0.7 are generally considered reliable) and a 'split-half' coefficient of 0.79.

There are differences between departments in terms of the job categories of respondents. Breakout's respondents appear to be an even spread of managers, professionals and administration staff. Sourcing appears to be a management suite with only 2 respondents that are not managerial grade. The property department appears to have equal numbers of managers and professionals but is either not supported by administration or administrative staff did not respond.

Department * Work Type Crosstabulation

Count

		Work Type						Total
		Executive/Senior Manager	Manager	Professional /Technical	Administration	Other		
Department	Not Specified		1					1
	Property	4	4	8		1		17
	Breakout	2	7	6	5	1		21
	Sourcing	2	6	1		1	1	11
Total		8	18	15	5	3	1	50

We are not clear whether these differences are real or whether they suggest a cultural difference between the groups. Do administrative staff in Breakout feel more able to respond?

Results

Working preferences

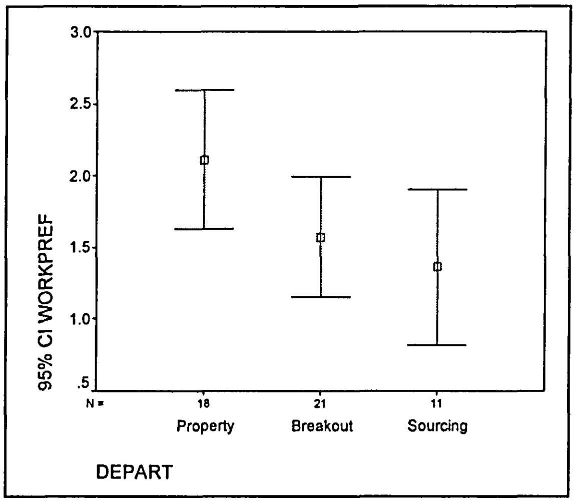
When asked do you / would you want to work?

a) from home on odd occasions
b) on average of 1 or 2 days a week
c) from a work location close to home?

Forty seven (94%) responded yes to option a), 32 (64%) to b) and 23 (46%) to c). Of the last group 20 also answered yes to option b). Only one individual, perhaps unsurprisingly a male senior manager, responded negatively to all three options.

When asked which of the following would be the most preferred working arrangement?

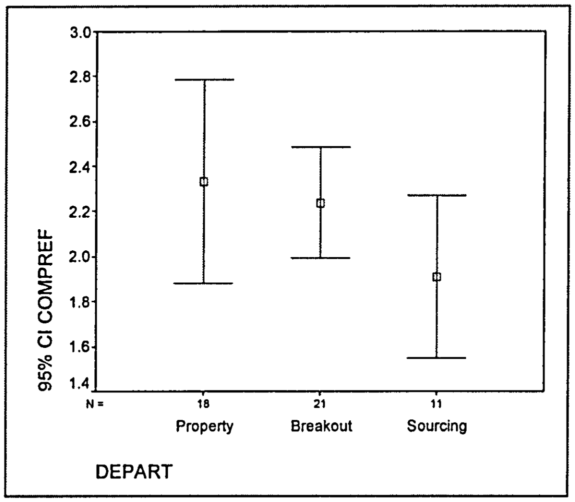
a) Your own workstation
b) A workstation shared with one or more colleagues on a team basis
c) Use of desk space when needed and access to quiet working areas in the office when needed



Thirty two preferred a), 16 c) and only 2 b).. Of those nominating c) 6 came from 'breakout' 8 from 'property' and 2 from 'sourcing'. Both b) responses came from 'property'. The sample sizes are such that a statistically significant difference cannot be proven, but the plot of mean preferences and ranges (left) does suggest a difference. Note that the options have had to be assigned numeric values such that A =1, b=2 and c=3.

When asked what would the most preferred computing arrangements be?

a) Use of PC
b) Use of a lap-top and docking facilities
c) Both



There is a strong preference for either b) or c) with only 8 responses preferring a). Again statistical significance to the differences cannot be proved but the preference for PCs seems marginally more marked in 'Sourcing.

Office environment

Eighty percent of respondents consider that, relative to other factors that can effect their work performance the influence of office environment is high (29) or very high (11). Eight respondents said average and only 2 said low or very low (1 each). These figures are typical.

The major part of the questionnaire asks peoples' responses to a list of 27 variables describing their office. Although the questions is deliberately phrased to focus on peoples' perceptions of their productivity, viz *"in your opinion, in your current office, what effect do the following office facilities have on your personal productivity?"* we are aware that respondents have a tendency to rate highly aspects of an office that is particularly appealing to them. The problem exists in all forms of service satisfaction research and does not yet have a satisfactory solution. It needs to be born in mind when interpreting individual surveys.

The overall average results for the 27 items in this survey are shown in the following table.

Variable	All	Breakout	Property	Sourcing
Work interactions	4	3.90	4.11	4.00
Physical security	3.88	3.86	3.89	3.91
Work area (i.e. desk)	3.88	3.76	4.00	3.91
Formal meeting areas	3.82	3.81	3.89	3.73
Overall atmosphere	3.8	3.86	3.78	3.73
Social interaction	3.8	3.71	4.06	3.55
Natural light	3.7	3.43	3.83	4.00
Position relative to colleagues	3.64	3.62	3.67	3.64
Overall physical comfort	3.64	3.67	3.83	3.27
Decor	3.54	3.76	3.61	3.00
Creative physical environment	3.52	3.33	3.83	3.36
Personal storage store	3.5	3.62	3.33	3.55
Informal areas	3.48	3.48	3.78	3.00
Overall office layout	3.48	3.14	3.83	3.55
Ventilation	3.42	3.19	3.39	3.91
Position relative to copier etc	3.42	3.29	3.50	3.55
Refreshment points	3.4	3.57	3.44	3.00
Quiet areas	3.4	3.19	3.83	3.09
Heating	3.36	3.43	3.17	3.55
Space allocation	3.34	3.33	3.17	3.64
Circulation	3.34	3.38	3.22	3.45
Cleanliness	3.3	3.19	3.17	3.73

Artificial lighting	3.28	2.90	3.50	3.64
General storage	3.18	3.19	3.11	3.27
Privacy	2.9	2.90	2.67	3.27
Noise	2.76	2.71	2.61	3.09
Interruptions	2.48	2.43	2.44	2.64

Work interaction emerges as the most positively ranked variable as it does in every normal office we have surveyed in either public or private sectors. Work area, as in other surveys, is also highly rated. We interpret this finding as indicating again that interaction, primarily if not exclusively through conversation is a, or even the, key 'production' process in knowledge environments. It is noticeable that these positive variables are more highly scored in 'property'.

Equally unsurprisingly variables concerned with interruptions receive the greatest negative response, confirming again the need in modern offices to manage the interaction distraction ratio. The values for both Noise and Interruptions in two of the three spaces are lower than we have observed in other offices, including those adopting flexible desking practices. By way of example, only 3 respondents from 'property' rate interruptions as positive. Our best exemplar of a flexible office has 33% offering a positive or very positive response to this item. The inference is that flexible protocols to allow concentration (in or away from the general office) have been underdeveloped.

Also of note in two of the distraction variables (privacy and noise) is a higher score in 'sourcing'. 'Breakthout' with 5 out of 21 respondents in cellular office and 'Sourcing' with 3 out of 11 report similar percentages suggesting that style of office per se is not the explanation. There may be a difference on the ground that would merit investigating.

Physical security, here in second place is normally highly ranked but the average in this survey is slightly higher than in any other site so far examined. The reason is not clear.

To examine the data we process the results using a method called factor analysis that essentially reveals groups of variables that tend to get correlated responses.

Rotated Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
Work Interaction	.801							
Social Interaction	.675							
Creative Physical Environment	.611							
Position Relative to Colleagues	.593		.400					
Overall Atmosphere	.569							
Physical Security	.489		.446					
Decor	.487			.457				
Interruptions		.760						
Privacy		.742						
Workarea, Desk		.610						
Crowding		.560						
Noise		.557		-.526				
Overall Comfort	.419	.423						
General Storage			.869					
Personal Storage			.837					
Quiet Areas				.848				
Informal Meeting Area				.758				
Heating					.842			
Ventilation					.626		.604	
Cleanliness					.611			
Position Relative to Equipment						.786		
Refreshments						.769		
Circulation Space						.438		
Natural Light							.835	
Formal Meeting Area							-.508	.431
Overall Office Layout								.746
Artificial Light							.534	.535

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. *Rotation converged in 19 iterations.*

The table above, known in the statistical terminology as a rotated correlation matrix, shows the result. The factors are identified in the order of the amount of variation they explain: i.e. factor 1 explains the largest variance and so on. The numbers refer to the strength of the correlation between individual variables and others. Interpretation of any factor analysis is always somewhat subjective. Some authorities suggest correlations of 0.4 or stronger should be considered. Others, especially with smaller data sets argue for a higher threshold. In the above table we show all correlations with the smaller threshold.

The first factor clearly associates, as would be expected, variables that influence interaction while the second, equally clearly, associates variables relating to distraction. This is as predicted and confirms other studies. The first two factors between them account for 36% of the total variance in the sample.

Also, as found elsewhere, there is a correlation between what we term informal interaction points.

It is the variables that contribute to Interaction that are perceived as having the biggest differential impact in 'property'. This leads us to suggest that it is the workplace design rather than merely the existence of a new workplace (a Hawthorne effect) that explains the change.

While the core variables remain the same in this sample as elsewhere, there are specific differences, highlighted below in italics.

Factor	***Variables Loading (overall data)***	***Variables Loading (xxx sample)***
Interaction	*Social interaction, work interaction, physical security, creative physical environment*	*Social interaction, work interaction, physical security, creative physical environment,* overall atmosphere, decor, comfort, position relative to colleagues
Informal interaction points	*Position relative to equipment, refreshment areas*	*Position relative to equipment, refreshment areas,* circulation space
Environmental services	*Ventilation. heating,* natural lighting, artificial lighting	*Ventilation. heating,* cleanliness
Office layout	*Personal storage, general storage,* work area, desk, overall office layout, *position of colleagues,* circulation space	*Personal storage, general storage,* Position relative to colleagues, physical security
Comfort	*Décor, cleanliness, overall comfort*	Not seen as separate factor
Flexible space	formal meeting areas, *informal meeting areas, quiet areas*	*informal meeting areas, quiet areas*
Distraction	*Interruptions, crowding, noise, privacy,* overall atmosphere	*Interruptions, crowding, noise, privacy,* work area, comfort
Formal meeting areas	Not seen as separate factor	Strong, negative correlation between formal meeting areas and ventilation, natural and artificial light.

Interaction Distraction

As seen in other research Interaction is perceived as having the most positive impact on productivity. Distraction the least, though here there is a wide range to the distraction data.

Both these factors appear reliable with Alpha values of 0.78 and 0.79 respectively.

It is notable that the overall atmosphere, in xxx, is associated with interaction, whereas in our reference data set from the UK the overall atmosphere is associated with distraction!. It is tempting to suggest a cultural difference. On the other hand work areas in xxx tend to be seen as sources of distraction, and comfort is polarised. It seems that there is one group (across all three business units) who find a lack of privacy uncomfortable and a second group less concerned by it.

The other unusual feature of this survey is the strong negative correlation between formal meeting areas and the lighting and ventilation variables. It poses the question as to whether the formal meeting areas are seen as poorly lit and ventilated.

Types of work

We have observed in UK samples that people who see themselves as falling into DEGW's Transactional Knowledge Worker' category - that is as seeing themselves having a high degree of job variety and autonomy - are on average much more positive about their perceptions of workplaces. We emphasise perception here because, in our studies, the 'transactional knowledge workers' come from the same range of occupations as do other 'groups'. We believe the difference reflects issues of culture and personality more than actual job type. We examined perceptions in this sample.

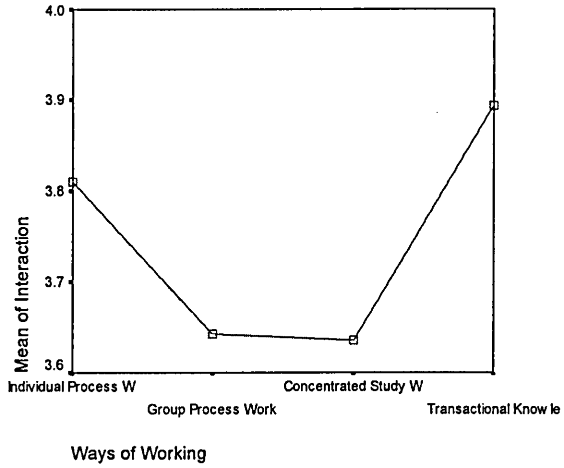
Department * Ways of Working Crosstabulation

Count

		Ways of Working				Total
		Individual Process Work	Group Process Work	Concentrated Study Work	Transactional Knowledge Work	
Department	Not Specified			1		1
	Property	7		8	2	17
	Breakout	9	2	5	5	21
	Sourcing	2	2	6	1	11
Total		18	4	20	8	50

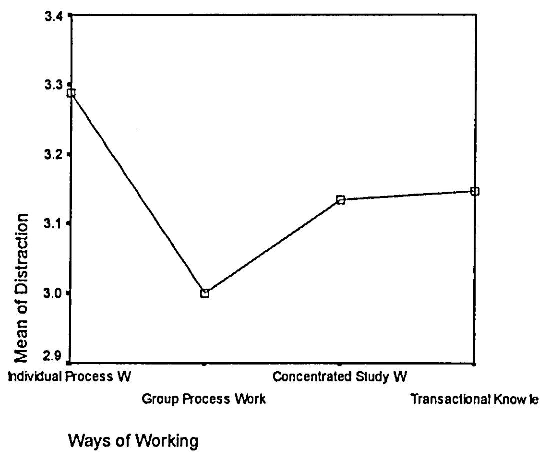
The two clear styles of working which emerge are individual process working and concentrated study; i.e. less than 60 % of time spent interacting with others and low or high perceptions of autonomy. The break out department appears to offer the widest range of work styles. This could be because it houses the widest range of job types. It also has the highest number of transactional knowledge workers.

The property department has the highest number of concentrated study workers and also has the second highest number of individual process workers. This could be because this department's response consists largely of managers or professional/technical personnel. The sourcing department has 55% of its staff working in a concentrated study. This may reflect the fact that the responses were largely from senior managers and managers.



The transactional knowledge workers report the highest perceived impact of interaction on their productivity. The individual process workers record a similar average. All groups perceive that interaction is having a positive effect on their productivity (i.e. > 3).

We cannot assign a meaningful confidence limit to these results with the sample size available



Similarly no significant differences between the effects of distraction can be confirmed for the different ways of working. The results indicate that the individual process workers perceive distraction as having the most positive effect on their productivity. Using 3 as the neutral point, it can be seen that both concentrated study and transactional knowledge workers perceive distraction as having a positive effect on their productivity. It is only the group process workers that do not see distraction as having a positive effect on their productivity, although they do not see it as having a negative effect either.

Qualitative data

The final section of the survey deliberately offers an opportunity for open ended comments which, here as elsewhere tend to re-enforce the messages from the closed questions.

The Breakout Unit clearly have a concern about being split in two

- *The team is segregated and does not lend itself to quick and easy collaboration There no lunch/common rooms to sit and have a chat, eat together watch television read magazines etc- Not enough storage for personal items/ books binders etc at the desk (have to store it other places)*

- *Our team is split up on the floor so there is less interaction with people down the other end - which has a negative impact on team dynamics I also find it hard to work at my desk without interruptions - sometimes work from home when I need to concentrate on a report etc.*

- *Would be nice if all our teams were close together instead of being the other side of the floor with other dept between us*

- *Not suitable area for downtime lunches to socialise Breakout team should sit together in one section of the floor (rather than scattered between)*

about natural light

- *Natural light is very important*

- *Having a desk without "sides is really awkward - it always feels messy and there is no space for on desk storage - it is also very open and hard to demonstrate through body language that I am working and don't wish to be interrupted (when I am)*

- *The people have a big impact on my work. The energy they create is important to my own energy level. It would be great to have some natural light and air.*

and, for some at least, about interruptions

- *Many interruptions make it difficult to do "thinking work". I sit near the kitchen therefore people who come for a cuppa stop for a chat too.*

- *My desk is situated next to the kitchen area - I rarely have more than 10 minutes without interruption. As a result I work from home once a fortnight for creative time and project style work. If I had access to a small quiet space where I could work without interruption could still be in the office and be available for discussions with my team as required.*

- *Although I really like working within a team the open layout of the floor and the close proximity of the work stations means constant interruptions distractions and the noise affects my ability to completely focus*

- *Very noisy & find it difficult to concentrate at times.*

- *Having my own office means I can concentrate on the issues I have to deal with when I need to - and am also available to my people through my open door policy*

The Property Unit are generally more inclined to favourable comments

- *Provides a range of alternate work settings which meet different needs over time.*

- *great for team work and collaborative work*

- *Having previously worked for many years in an enclosed office I find the open-plan approach to workspace improves my overall productivity enormously as I am not working in a vacuum*

- *The current environment has forced me to become more productive in terms of document and filing management* though the issue of different personal preferences does appear

- *Higher noise levels in open office space is an issue for people who are easily distracted by noise. This has a negative impact on their productivity.*
- *Since we do not have allocated desk storage of daily used work documents is a huge issue. There is not enough of it per person and it is not secure enough (plastic covers on cabinets and cheap locks).*
- *Air conditioner works on very cold temperature and I feel all the time cold and its make me rush to home..*

Sourcing made fewer comments, generally favourable

- *Quality of fittings and furniture needs to be considered. I've no objection to working in open environments if I have plenty of workspace - large workstations are helpful.*
- *This office is best I have worked in. Has plenty of 'equipment' and space. Just needs a more modern colour scheme to 'brighten' up our lives. I have been provided with all the work tools I require - excellent. I am on Level 21/100 QSM*
- *Generally speaking it affects my work performance positively.*

A final question on any other comments generated a few, largely specific, responses, which have been supplied but not included here in case they might breach confidentiality.

Discussion and suggestions

The importance of interaction as the factor perceived as having the highest impact on productivity has been confirmed, as has the perceived negative effect of interruptions.

There is a positive effect of enhanced interaction seen in 'Property' as compared to either of the other business units, especially in terms of the creative environment, the informal interaction points and the provision of quiet areas. A higher density layout is confirmed as also being seen as more conducive to productive work.

Distraction is however still seen negatively by a large number of people, especially in both 'Breakout' and 'Property', and also by those who feel a negative lack of privacy. Whether or not there is an influence of office layout cannot be assessed, but should be considered.

Two other influences may exist.

Firstly, it seems there is a widespread feeling that more opportunities to work from home, or from a local satellite office would be welcomed, yet in the comments only 2 individuals mentioned actually doing so, in terms which suggested it being an exception rather than a common practice. Other research into home or remote working has identified both on behalf of some home workers who admit to some feeling of 'guilt' and in the office where cultural pressure to 'be present' is often perceived, whether real or actual. It would be worth considering whether such unwritten rules still linger in practice, and even whether some individuals do not see themselves as being able to move to 'quiet areas' if a piece of work demands it.

Secondly, there may be an influence of personality. In other ongoing research we are finding that people with particular preferred styles, especially those of a more introverted or intuitive preference do develop a greater attachment to an individual space and find very exposed locations more intimidating. Where possible we recommend such preferences be accommodated in the allocation of work spaces, especially if there is a danger of the political dynamic still tending to offer the better locations, even within an open environment, to those with more power.

Whatever the reason, the productive effects of interaction in this survey compare with the best examples we have seen however we have surveyed offices where distractions, or positive interruptions, did attract more favourable comment. In terms of fully realising the available benefits of modern offices there would still appear to be opportunities to reduce the negative side effects.

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Haynes, B. and Price, I (2002) Quantifying the Complex Adaptive Workplace In J. Hinks, D S-S Then and S Buchanan Eds *Proceedings of the CIB Working Commission 070 Global Symposium,* Glasgow, Caber pp403-414 Appendix P: Reprint of journal paper

Quantifying the complex adaptive workplace

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Keywords

Work places, Office layout, Productive capacity, Open plan offices, Flexible working

Abstract

Despite well-publicised successes and failures, the evidence base for the impact of a workplace on an organisation's business performance remains small and confused. Theoretical perspectives are, with few exceptions, limited to matching physical environment to task. The concept from complexity theory of "edge of chaos" – a critical density of connectivity (Kauffman's K) between the agents in a network in which adaptability is maximised – may explain how workplaces enable, or retard innovation. Formal rectilinear open plan offices are conceived as freezing occupants in a state of connectivity as low as traditional cellular designs. Offices without minimal acoustic or visual privacy (high K) may create chaotic stress and reversion as individuals seek to recreate safety. In between are offices known to have enhanced informal conversation between their occupants and resultant innovation.

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Volume 22 · Number 1/2 · 2004 · pp. 8-18
© Emerald Group Publishing Limited · ISSN 0263-2772
DOI 10.1108/02632770410517906

Introduction

The term facility management (sic) was coined in North America during the late 1970s to describe a developing field of study into the design and management of workplaces and their impact on the business of organisations that occupied them. In crossing the Atlantic the same putative body of knowledge became known in the UK as facilities management and the original sense of workplace design came to be confused with the provision, and especially the outsourcing[1] of building support services (Price, 2002a). Early commentators stressed a complex and "ecological" stance on new workplace design (Becker, 1990; Becker and Steele, 1995) but the message has been largely lost and the current workplace debate focuses on "open-plan" versus "cellular" space (Haynes *et al.*, 2001), retains neo-Taylorist overtones (Duffy, 2000), is uncritical and apparently unaware of the post modern organisational discourse (Cairns and Beech, 1999a,b) without evidence of impact on all but the most mundane measures of productivity (Haynes *et al.*, 2001) let alone a theoretical framework for understanding same. Facilities, as opposed to facility management, has become a discipline and industry, dominated by building operations and maintenance (Lord *et al.*, 2002).

Yet there are well publicised descriptions of successes (Coutu, 2000), and of failures (e.g. Berger, 1999) and the suggestion, in a work of reasoned critique outside the main facilities literature, that physical space may be "the most important, yet least appreciated, tool of contemporary knowledge management"[2] (Ward and Holtham, 2000).

As new management tools, or fashions (Abrahamson, 1996), gain a niche in organisational discourse they attract proponents, managers, consultants and academic groups among others, whose interests are served by the continued spread of a particular fashion. Organisations emerge whose existence depends on propagation of the fashion involved (Price, 1999). One measure of the process is the growth

Thanks are due to Liz Clarke, Shaun Lunn, Cletus Moobela, Victoria Ward, Clive Holtham, James Pinder, Bill Thompson, John Storr and Rob Harris for stimulating discussions.

in the number of publications devoted to the subject as publishers, and authors, spot the new niche (Abrahamson, 1996; Abrahamson and Fairchild, 1999; Scarborough and Swan, 1999; Price, 2002b).

With some confusion of terminology between issues of workplace design, flexible working, and teleworking the trend may be seen in the current literature on workspaces. Occupiers are urged towards mobile or flexible futures. Perhaps even the continuation of the commercial office is in doubt. Yet, in common with many self-replicating managerial fashions, evidence is harder to find. The argument for flexible offices has been well established, with Becker (1990) and Duffy (1990) as the most noted pioneers. Offices or workstations are notoriously underutilised, even during normal working hours so their use by more than one person makes apparent economic sense. Different forms of work require different forms of space, so provision of same should raise effectiveness. Work is increasingly a series of formal and informal projects, requiring groupings of individuals for limited and variable periods of time. Space can facilitate such groupings; moving people but not fixtures.

At a more abstract level, modern organisations are increasingly perceived as ecosystems rather than machines: systems in which tacit knowledge is developed and exchanged through conversations, formal and informal. Conversation, in a broad sense of exchange of meaning, may even be a (the?) fundamental production process of a knowledge economy (Pascale *et al.*, 2000). Space that encourages effective conversations might speed up organisational learning. Knowledge management theory is beginning to regard the level of informal connection in organisations as an important part of the knowledge creation process (Palmer and Richards, 2000). Some degree of interaction in an office environment may be essential to enhance people's knowledge of the organisations they work for.

Yet the evaluation of workplace flexibility remains contentious (Vischer, 1999). Some go so far as to argue for a return to private offices (Olson, 2002). Independent academic studies (and they are few) are cautious. Cairns and Beech (1999a,b), while taking care not to "seek to deny that any of the concepts of flexible working may be truly valid and applicable", highlight the advocacy bias in many speeches and presentations on the subject. The revolution foreseen by the pioneers of FM has not materialised (Duffy, 2000) and the glittering prize remains out of reach for most office workers (Nathan and Doyle, 2002). Issues of organisational culture, foreseen by Becker (1990) remain under-appreciated (Hörgen *et al.*, 1999). Managerial attitudes are seen by those who have succeeded or failed with flexibility initiatives as the single most common determinant of the outcome (Lupton and Haynes, 2000; Price, 2001b; Laframboise *et al.*, 2003).

A fuller review (Haynes *et al.*, 2001) and a working paper (Price, 2001a) can be found on the www.occupier.org resource[3]. Our concerns in this paper are twofold. We present a theoretical stance which offers, we believe, a new means of explaining successful office designs. We then indicate, with early results, how that frame can be explored.

Towards a new theory

What is missing?

Open-plan offices, and more flexible "innovative" designs are not new, yet assessment of their impact remains contentious. If such designs are not the panacea their proponents promised then, if anything went "wrong", it was perhaps the attempt to proscribe and implement changes that were inappropriate. Alternatively, as successful cases suggest, more innovative workplaces may stimulate more innovative work, while helping attract and retain more innovative workers. If so, then in the knowledge based economy such workplaces should indeed be a lever to improved organisational performance; the "most neglected resource in contemporary knowledge management".

Duffy, recently (2000) reflected that the changes he and others anticipated 20 years ago have not come to pass:

> The skill of managing office space may have developed but the office environment itself remains very much as it was.

Duffy (2000) attributes the failure to conservatism by suppliers, to lingering Taylorism and associated hierarchical cultures in organisations, but most of all to a cost focus

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on the part of both facilities managers and design professionals:

> Programmes of research could have been initiated, using comparative data from cumulative case studies, to demonstrate the effectiveness, as well as the efficiency, of using the design of the working environment to achieve strategic business purposes.

Missing from this analysis is any theoretical framework concerning the impact of workplaces on the behaviour of those who use them[4]. The designer is still assumed to be an expert who knows what best suits the individual[5]. Even if Taylorist ideas are criticised, work is assumed to be something that can be planned and managed. Despite anthropological (Steele's (1988) "caves and commons" (Hurst, 1995)) and biological (Becker's (1990) "workplace ecology"), metaphors in the early workplace literature much of the debate is still framed in terms of "open-plan" versus the private office. Design is still predominantly considered as a rational rather than an emergent process. An epistemological stance which sees management and design as distinct activities (Leaman, 1992) still predominates in the professions concerned.

Beyond the rationalist paradigm

Parallel developments in evolutionary approaches to organisational sociology (Hull, 1988; Aldrich, 1999) and complex adaptive systems theory (Waldrop, 1992; Price and Shaw, 1998; Maquire and McKelvey 1999; Pascale *et al.*, 2000) are gradually coalescing to offer an alternative paradigm of organisations and their "management". They may be less intentional creations in which a dominant group exerts power over subordinates and more emergent phenomena maintaining boundaries[6]. While they keep a niche in a social and economic ecosystem, organisations replicate particular schemata or memeplexes (Price, 1995; Lane, 1996; Gell-Mann, 1996; Carney and Williams, 1997; Price and Shaw, 1998; Blackmore, 1999; Weeks and Galunic, 2003). The debate, and its implications for management practice, can be conceived as happening along a spectrum of explanations of what organisations are and how they should best be managed. One end of the spectrum is the traditional "mechanical" perspective. Management is a rational process of setting desired parameters, planning how an organisation will perform, and ensuring compliance. The other sees organisations as "living" systems, not just metaphorically but literally. Management is the act of creating contexts from which new knowledge and new results emerge. Particular events and actions are bound to be unpredictable and performance is judged in terms of whole system outcomes, not inputs (Price and Akhlaghi, 1999).

Equivalent debates can be found in other branches of social science. Economics is developing, some would say redeveloping, an "evolutionary" approach (Loasby, 2001) and behavioural research is even beginning to command attention in property valuation (Diaz, 1999). Psychology wrestles with the extent to which behaviour is "hard-wired" or socially constructed (Ashworth, 2000). However, despite the calls of some pioneers (especially Becker, 1990) most workplace research (such as there is) has stuck within a narrow, rationalist framework where hours saved or sheets of paper processed are seen as measures of productivity (Haynes *et al.*, 2001). It is the authors' hypothesis, based on this review that pushing harder and harder at what has not worked is unlikely to succeed. We need research, which starts with a different underlying paradigm, if we are going to reach any understanding of the interrelationship between workplace, organisational culture, and business results.

The alternative may be found in the emerging synthesis of evolutionary and complexity perspectives. There is obvious resonance between the complex systems perspective and the ecological view of workplaces proposed especially by Becker (1990). Such evidence as does exist for success stories points to links between a critical mass of informal interaction and faster knowledge creation (Haynes *et al.*, 2000). Can studies that start with that as a hypothesis explain the contribution of workplace to organisational success?

Connectivity in the workplace

Modelling of agent behaviour in complex systems (especially Kauffman, 1993, 1995) provides a possible clue. It suggests that in networks the behaviour of a system of N agents, each of which can have at least two states (e.g. on/off), depends on K: the proportion, or number, of agents whose current state influences the change of state of

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another. With low values of K systems are "frozen" to a particular state; i.e. highly ordered. As K, approaches 100 percent (or N-1), behaviour becomes completely erratic (chaos) with no sustained innovation. The greatest adaptability is seen in a relatively narrow value of intermediate "K", a phenomenon which has become known in complexity circles as "the edge of chaos" (Waldrop, 1992). The term has become one of the enduring messages, or metaphors, of complexity. The term gained its niche in organisational commentary, but has not, at least so far as search of current literature has revealed, been used to analyze office environments[7].

Much of the literature on "new ways of working" is framed in terms of open-plans and hot desks versus traditional cellular offices. Yet many open-plans reproduce rectilinear layouts in which individuals or small groups are provided with, or create for themselves, spaces that are as enclosed and private as the prevailing environment permits. They reflect a pattern towards the mechanical end of the spectrum. Meetings are conceived as formal events for which people go to a meeting room, not part of the routine of work. Connectivity remains low. At the other end of the spectrum are offices which are untidy jumbles in which perhaps individuals create refuges from local arrangements of furniture. Good examples are pictured by Nathan and Doyle (2002).

The alternative workplaces regarded as having succeeded supporting flexible working in a variety of workspaces, often with some degree of multiple use of individual workstations seem to send different visual clues. Describes instances resembling "teenager's bedrooms". They seem to permit connectivity while people are in the office, but home or various "caves" offer privacy. Currently it can be no more than a metaphor but are such workplaces somewhat disordered but not chaotic or frenetic: at the edge of chaos[8].

Connectivity can also be seen in the alternative debate on new workplaces: the one which distinguishes "caves and commons" and private rows (Steele, 1988; Becker and Steele, 1995; Hurst, 1995; Hargadon and Sutton, 2000) rather than open-plans and private offices. In "caves and commons' designs, individual workstations - or offices - surround or share informal common space in which frequent informal interaction occurs. Work is a system of fluid conversations and workers move to whatever environment is needed for a particular conversation, or simply find themselves exchanging information by chance[9]. Again some critical mass of connectivity is achieved[10]. The Complex Adaptive Workplace perspective would argue that caves and commons sustain a higher degree of connectivity.

Research

Hypotheses

The above model leaves the following hypotheses to be tested:

H1. New workplace initiatives succeed when they enable some critical density of spontaneous interaction. Too much and the distractions outweigh the benefits. Too little and benefits are not seen. That critical density may vary with sector and type of work.

H2. Realising the success will depend on the culture of the organisation and will be greatest in organisations who have most successfully adopted "new" managerial patterns. Contrast Turner and Myerson's (1998) mould breakers, those who have succeeded because they challenged, or were unconstrained by, the traditional patterns of a particular sector, from their modernisers, those who changed the office but not the thinking that went with it. The success to be realised will be a factor of the extent to which "new" cultures are a contributor to relative organisational success. Those who have implemented new office and workplace initiatives without changing old cultures will see less value (and perhaps negative returns) from the investment.

Methods

Where studies of occupants' perceptions of their office environment have been published they have tended towards either a purely positivist occupier survey or to a blend of such surveys with either physical or cost-based assessments of building performance. Phenomenological, or at least phenomenologically leaning, studies of workspaces or the interplay of workspace and culture are only beginning to appear (Hörgen *et al.*, 1999; Lupton and Haynes, 2000).

Observational research is conspicuously absent from the 1990s literature (Haynes *et al.*, 2001). In part the problem may reflect the multi-faceted nature of FM research, blending as it does the research traditions of economics, sociology, building physics and psychology. The hypothesis, is that "knowledge productivity is a function of commonality, culture, and connectivity".

Fully testing such a model is clearly multi-faceted and requires, inter alia, analytical tools for space classification, assessment of work cultures, and the elusive "holy-grail"; a means of measuring the rate of knowledge creation in organisations. Price (2001a,b, 2002c) has a longer discussion. The aim of developing an indicator for assessing the impact of office facilities on productivity formed the basis of one of the author's PhD research (BH). An opportunity to collect raw data was however provided during work for FMGC's Local Government Research Forum.

In doing such research, which is almost inevitably questionnaire based, analogies can be drawn from the literature on customer expectations and quality (Robledo, 2001) where one school, the disconfirmationists, regard importance and satisfaction as independent variables, hence SERVQUAL (e.g. Parasuraman *et al.*, 1988). In contrast perceptionists would hold the two to be simultaneously measured by questions of relative performance; Cronin and Taylor's (1992) SERVPERF.

Previous evaluations of office environments have tended to a disconfirmationist approach: i.e. have sought to measure the expectations of occupiers and their satisfaction in separate instruments. In the process, links to productivity have become indirect. We opted instead for a perceptionist approach devising a research instrument which asked respondents to assess their perceptions of 27 variables on their individual productivity. The questionnaire provided scope for each to be assessed on a five point Likert scale from very negative to very positive. A series of categorising variables sought information on the individual respondents in order that results could be analysed by job type. Questionnaires were distributed in 27 local authority offices, introducing the possible bias in that participating facilities managers were volunteers. A total of 996 completed returns equated to a 22.9 percent response rate; acceptable in work of this kind (Hussey and Hussey, 1997).

Initial results

Overall, a Cronbach Alpha of 0.9485 pointed to high internal consistency and indicated reliability of the test instrument[11]. A correlation matrix revealed a substantial number of correlations greater than 0.3 and a commonalities table showed 89 percent of commonalities scoring more than 0.5. These and a significant Bartlett test of sphericity all pointed to responses from a population of independent variables suggesting Factor Analysis as an appropriate analytical tool[12]. A Principal Component Analysis was chosen as we aimed to determine the minimum number of factors needed to account for the maximum identifiable proportion of the variance in the original data set.

Interpretation of factors is ultimately subjective (Hair *et al.*, 1995) with a trade-off between number and variance explained. In the event we settled on 7 (see Table I and Figure 1), explaining 69 percent of the variance. Two distinct groups can be recognised, the tangibles and the intangibles, corresponding closely to the McDougall and Hinks' (2000) distinction of service and socio-spatial conditions. Tangible components, environmental services, office layout and perhaps "flexible space" relate directly to the individual and physical environment and are similar to those revealed in earlier studies (Leaman and Bordass, 2000). The components "Distraction" and "Interaction" appear to point to more intangible or psychological factors; indeed they may be a insight into the social construction of individual offices (see below). "Comfort" verges more to the tangible, as at first glance does the factor "informal interaction points", though the two items involved are perhaps the most common sites of informal conversation. Where the factor extraction set is reduced, the two items concerned load with other interaction factors.

Cronbach Alpha coefficients were calculated for each factor, and as can be seen from Table I support the robustness of most. The component "Informal interaction points" has a relatively low coefficient, which we take as an

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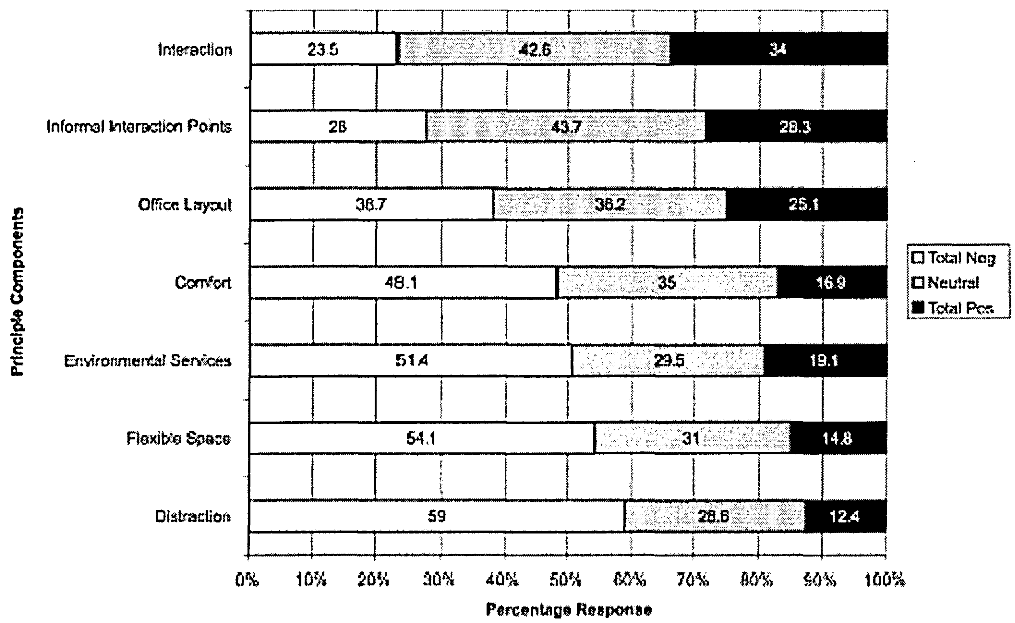
Table I Loading of variables with principal component extraction at 7. Cronbach Alpha reliability scores for each factor are shown. Factor names (first column) were assigned by the authors

Factor	Variables loading	Cronbach-Alpha
Distraction	Interruptions, crowding, noise, privacy, overall atmosphere	0.8478
Environmental services	Ventilation, heating, natural lighting, artificial lighting	0.8037
Office layout	Personal storage, general storage, work area, desk, overall office layout, position of colleagues, circulation space	0.8469
Interaction	Social interaction, work interaction, physical security, creative physical environment	0.7943
Flexible space	Informal meeting areas, formal meeting areas, quiet areas	0.8469
Comfort	Décor, cleanliness, overall comfort	0.8690
Informal interaction points	Position of equipment, refreshment areas	0.5726

Figure 1 Overall ratings of the perceived impact of different factors on productivity



indication of heterogeneity in the sample and are investigating further.

Figure 1 summarises the overall responses for each factor. Total negative and positive scores combine scores for two scale categories each. It is immediately apparent that the interaction factors are seen as scoring more positively, whereas distraction scores most negatively. We have not yet been able to examine the "flexible space" factor in follow-up interviews for this data set; given the sector, we suspect that respondents are reacting to the lack of such space and the resulting distraction, or possibly to a "meetings culture".

More generally the factors suggest a positive effect, on perceived productivity, of interaction, and a negative effect of distraction. While not surprising, and consistent with the inferences drawn above from the literature, these results do suggest that conventional occupancy analysis, which has historically tended to concentrate on the tangible, may often have failed to examine the more important influences of office design on productivity. One important exception (Olson, 2002) likewise identifies the ability to do distraction-free work and interactions as the two biggest factors impacting individual performance, team performance and job satisfaction. Olson (2002) however draws the conclusion that private offices are superior to "open-plans" but appears to equate open-plans with rectilinear cubicle plans, ignoring completely alternative designs.

We, by contrast, would argue that the interactivity to distraction ratio appears compatible with the edge of chaos model. Too little of the former (order) and productivity, as measured by individual perceptions, suffers. Too much of the latter (chaos) and the negative effects of distraction dominate.

The research instrument also sought to classify responders according to their gender, type of work and mode of working. Investigations continue to examine the validity of the above factors according to different categorisations, particularly the mode of working. Here the best known, in the UK at least, is Duffy's/DEGW's characterisation of four groups (Laing *et al.*, 1998) according to the variables interaction and autonomy, defined as:

> *Interaction* is the personal face-face contact that is necessary to carry out office tasks. As the amount of interaction increases, there is more pressure to accommodate and support such encounters.
>
> *Autonomy* is a degree of control, responsibility, and a discretion each office worker has over the content, method, location, and tools of the work processes (Duffy, 1998, p. 60).

and producing the categories of individual process, group process, concentrated study and transactional knowledge work. In order to recreate the four different subsets of this matrix, the questionnaire asked:

- What percentage of time do you spend with colleagues?
- How much flexibility do you have to work where, when and how you wish?

The first question aimed to establish the amount of interaction the individual has with their work colleagues when they are in the office and offered a choice of percentage ranges. The second aimed to establish how much autonomy the individual has with regards to how they work with possible answers on a five point scale from very low to very high. The total dataset was then split into the corresponding subsets using the criteria shown in Table II.

Column 2, in Table II, allows the data to be split using the variable flexibility, i.e. autonomy. Therefore people working in individual process or group process work have very low - average amount of flexibility as to how, when and where they work. However people working in the concentrated study and transactional knowledge modes, have a high - very high amount of flexibility as to how they work in the office. Column 3 splits the data by establishing the amount of interaction an office worker has with their colleagues. People working in the individual process and concentrated study modes spend less than 60 percent of their time working with colleagues. Alternatively the people that have the work methods Group process and Transactional knowledge spend more than 60 percent of their time working with colleagues. The final column, in Table II, represents the sample size that corresponds to the appropriate way of working.

Having created the four comparable subsets; a factor analysis was undertaken for each subset to establish if unique factors are created for each subset, or if the factors created in the total subset are reproduced in the subsets, thus supporting the validity and the generalisability of the original factors. Since this part of the research process is more confirmatory, then each of the new ways of working subsets was analysed with the factor analysis convergence model set at seven factors (Table III).

The same components load in each category, with the exception of the office layout factor for those who report high levels of autonomy in where they work: i.e. are likely to be mobile. Note, however, the strong correlation for this group in the interaction factor. The test reported examines reliability, i.e. the correlation between responses of randomly split portions of the sample. It does not measure importance - further examination is planned - but does indicate a high uniformity of view. In general the reliabilities are high for all factors and work types, though the impact of Informal interaction points appears to vary more in perceived significance, especially for individual processors. At this stage we take the results as encouraging support for the validity of the constructs identified.

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Table II Ways of working criteria adopted for this study

Way of working	Flexibility (autonomy)	Time with colleagues (interaction)	Sample size
Individual process	Very low – average	< 60 %	418
Group process	Very low – average	> 60 %	302
Concentrated study	High – very high	< 60 %	184
Transactional knowledge	High – very high	> 60 %	93

Table III Component loading and reliability (Cronbach Alpha scores) for staff reporting engagement in different modes of working

	Ways of working			
Component	Individual process	Group process	Concentrated study	Transactional knowledge
Distraction	0.8115	0.8880	0.7590	0.8345
Comfort	0.7111	0.8927	0.8664	0.8721
Flexible space	0.8073	0.8443	0.8579	0.8789
Interaction	0.8115	0.8442	0.8547	0.9071
Informal interaction points	0.4913	0.6703	0.7916	0.691
Environmental services	0.7989	0.8552	0.7764	0.7784
Office layout	0.8535	0.8534	0.8095	No component

Future work

Having validated the responses, work continues to investigate difference in importance between different groups of workers. Spider plots (an example is shown in Figure 2) provide a potential tool to calibrate individual offices on the interaction/distraction ratio. We have noticed that those staff who describe themselves as meeting the transactional knowledge worker category report significantly higher perception of productivity, but display essentially the same range of occupation types as other groups. Full discussion and analysis will be presented separately (Haynes in prep.) but the implication appears to be that ways of working cannot be simply correlated with job types.

Other surveys have now been conducted. The same factors appear in commercial offices, albeit with subtle and locally important differences in emphasis. We have had one opportunity to contrast offices displaying ordered, chaotic and edge of chaos styles in adjacent buildings belonging to the same company; i.e. in a situation where differences in culture, while still possible at a micro level are minimised. The edge of chaos workplace reveals the highest net positive response (over 90 percent) yet recorded and a 33 percent net positive score for distraction strongly indicating a situation where informal connectivity is valued. Work is also under way (Haynes, in prep) to examine whether perceptions differ according to personality. The survey instrument has been modified to include an opportunity for open-ended textual comments. Again provisional results support the factors derived above. The importance of such studies is obvious. We are also seeking opportunities to further integrate such testing with other forms of spatial and sociocultural analysis. These results are not reported as a single panacea. There are obviously differences in how individuals and groups perceive and construct workplaces and evaluation of same cannot be divorced from wider fields of organisational culture. That said the results do provide evidence supporting both the informal view that what counts in offices is casual interaction, and also confirm the potential for modelling same using tools from complexity science.

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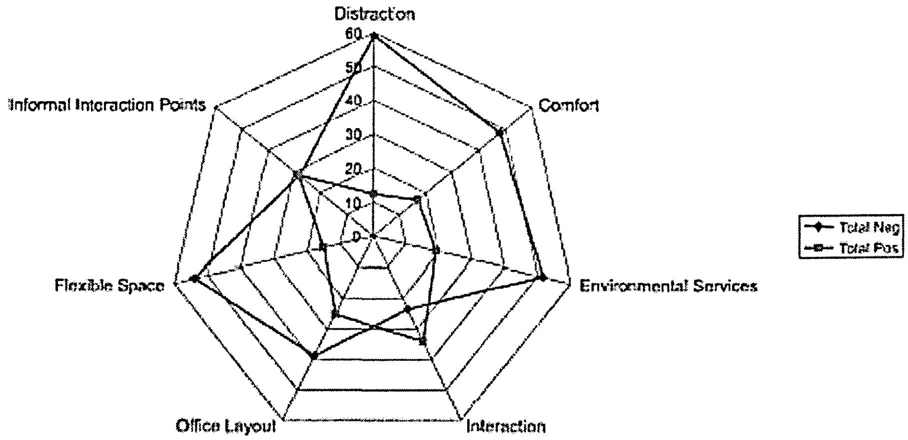
Figure 2 Spider plots of average scores on the seven components for all offices in the survey



Notes

1 "Facilities" is the older term having been employed originally to describe the outsourcing of data processing activities from 1968.
2 Victoria Ward (personal communication, 2002) ascribed the quotation to Tom Peters.
3 In response to comments from an anonymous reviewer we do not imply little work having been undertaken on the effectiveness of open-plan offices. We do imply that major gaps remain in terms of understanding their impact on business performance (Haynes *et al.*, 2001).
4 That the design of the office matches the degree of autonomy granted the worker and the interaction demanded for the tasks they are required to carry out.
5 This may be changing. Hörgen *et al.* (1999) advocate "process architecture", an engagement by the designer with the unwritten rules of the organisation while Blyth and Worthington (2001) stress the development of strategic briefs as an iterative process. Laframboise *et al.* (2003) highlight the importance of communication and involvement in successful implementations of property initiatives.
6 We might here be accused of ignoring a widespread and broadly "post modern" school of organisational commentary which queries single normative approaches and encourages more reflective engagement with the multiple constructs and discourses in "workplace". Such is not our intention, however, comparing the socially constructed and evolutionary standpoint would take us beyond the scope of this paper.
7 Ward and Holtham's (2000) conception of knowledge management and knowledge environments as complex adaptive systems comes closest but ultimately goes in a slightly different, albeit interesting direction. They cite Swedish research by Tornquist as arguing for creative milieux having a certain density of communication with a kind of overcrowding and chaos.
8 Our own offices in FMGC (also profiled online) are designed on similar principles.
9 The view that professionals get 80 percent of their ideas through casual interaction has been much repeated but I have not found it further researched.
10 Undoubtedly other factors, especially culture and management attitude are important. Turner and Myerson (1998) refer to "modernisers", corporations who have moved to fashionable new offices but where "Staff shuffle uneasily down foliage filled avenues unsure whether sitting and chatting to a colleague over a cappuccino on a designer bench will be interpreted as slacking or having an informal meeting".
11 A standard measure of questionnaire reliability in research of this sort, derived from the internal consistency between individual responses. Values above 0.8 are generally considered as indicative of high reliablity.
12 Factor analysis can of course be criticised on the philosophical ground that it produces results whether or not what is revealed has real meaning.

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